INDEX TO SCIENCE CONSPECTUS VOL. III

Index

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SHALL WE EAT RAW OYSTERS?

SOME FACTS ABOUT THE LIFE, HABITS AND SURROUNDINGS OF THE OYSTER AND AN INQUIRY INTO THE SERIOUS CHARGES MADE AGAINST IT

BY EARLE B. PHELPS

THE oyster is a nutritious, wholesome and economical food, or it is a positive menace to the health of the community, according to the particular side of the question which one happens to read. In the daily press, in the magazines, and before meetings of learned societies, the oyster question is being discussed with an enthusiasm that is not always tempered with exact knowledge, or with a regard for the finer niceties of logic. It often happens that the innocent onlooker suffers more seriously than the active combatants and it is especially so in this case. The humble seeker after knowledge learns that oysters are contaminated, that oysters are safe, that he must know the source of the oysters he eats, that oysters are good in one month and bad in another. In despair, he either abandons oysters, or eats oysters and abandons hope.

The time seems opportune, therefore, for a brief statement of the known facts about the oyster's life habits and surroundings, and an inquiry into the serious charges made against it.

The oyster begins his life, in our northern waters, about the middle of August as a free swimming microscopic organism at the surface of the sea. After enjoying a few days of travel, he settles down upon the bottom and in the great majority of cases his life history is completed. If by good fortune he finds himself at rest upon some hard surface, which prevents his sinking into the muddy bottom, he immediately attaches himself to that surface and proceeds to grow. Old oyster shells form the most favorable substratum for his future development, but boulders, tin cans and even bits of wood will serve. At this stage of his life, the oyster is barely visible, and appears as a small brownish spot upon the white surface of the shell (figure 1). His growth is rapid now. Within a week he has attained a diameter of a quarter of an inch and appears as in figure 2. One week later he is nearly one-half inch across as in figure 3, while at the end of five weeks he has attained the dimensions of a five-cent piece, and has begun to feel somewhat crowded upon the old shell as figure 4 shows.

At this age the oysters are known as "oyster seed" and are an established article of commerce. Clean shells are spread upon favorable bottoms to secure a "catch" of the spat. These are later removed from the bottom and often shipped hundreds of miles to be replanted.

Under the laws of most of the oyster-growing states, oyster ground may be leased from the state for the purpose of securing seed or of raising mature oysters. Seed is also gathered from natural beds, especially in the south. After the first winter, the young oyster grows more slowly, and in northern waters requires three years for development to market size. During this time, however, the growing beds are frequently worked over by dredges in order to break up the clumps of oysters. Frequently also the oysters are all dredged up and distributed on some other ground, more favorable for their final development. Oyster culture, as it is carried out today, is as complex a matter and requires as much expert knowledge as the cultivation of the land. From the first securing of the seed to the final harvesting of the crop, the processes are always under watchful control and careful supervision.

The oyster, especially when young, has many natural enemies besides man. "Drum-heads" crush the shell, boring shell-fish perforate it, and the beautiful but parasitic star-fish slowly but irresistibly draws it open to feast upon its juicy body. Certain sponges have the power of dissolving the shell, and other small growing things live upon it and even within it without doing any apparent harm.

The oyster feeds upon the microscopic life which abounds in the water. Large volumes of water are drawn through the mantel cavity, and the food material is abstracted by a process of straining through fine cilia. These cilia are in constant motion, carrying the collected particles toward the mouth. These feeding habits obviously provide also an excellent mechanism for collecting germs of disease from a polluted water, and transmitting them to the consumer.

The belief that oysters may at times bring about sickness is older than the germ theory itself. It is difficult to interpret the earlier records but there is evidence of unhappy results following the use of oysters that had been kept too long out of water. On the other hand there is some evidence even in the older records that intestinal disorders of bacterial origin have resulted from eating oysters. Perhaps the earliest positive proofs of this belief was given by Professor Conn of Wesleyan University in 1894. Since that time many epidemics of typhoid fever have been traced beyond reasonable doubt to the eating of infected shell-fish. The most recent of these, and one of the most interesting, has just been reported by the United States Department of Agriculture in its Bulletin 156. Seventeen cases of typhoid fever and eighty-three cases of gastroenteritis were traced to oysters served at a banquet at Goshen, N. Y.

These epidemics constitute the evidence against the oyster. A much worse case can be made out against water, and milk, and perhaps some other foods. In the case of milk, there are not only many demonstrated epidemics of typhoid fever, but also of scarlet fever, measles, and many other contagious diseases, to say nothing of the constant menace of tuberculosis. Yet we continue to drink water and milk and to live. The fact is these demonstrated cases of oyster epidemics have in every instance been traced to conditions which are preventable, and for the existence of which some one should be held liable. The Goshen epidemic was shown to have resulted from the eating of oysters taken in the polluted waters of Jamaica Bay, New York City. In 1905 Soper traced a severe epidemic occurring at Lawrence, L. I., to oysters from the same source, and pointed out the polluted character of the Jamaica Bay waters. Again in 1908 the New York State Board of Health in a general investigation of the oyster waters of the state remarked upon the grossly polluted condition of Jamaica Bay. Despite these warnings and the obviously dangerous character of Jamaica Bay waters, which from time to time have been pointed out by various other investigators, it seems to be nobody's business to prohibit the sale of oysters from this source, so we have had this latest epidemic and shall doubtless have others until the lesson be learned.

This is not an isolated instance. The

Figure 1. Young oysters recently attached to an old shell—August 29

Figure 2. Same "catch" of spat one week later—September 5

Federal Government has pointed out equally undesirable conditions in our own state of Massachusetts, where one of the largest clam areas of the state, if not of New England, is located at the mouth of our most polluted river. This condition, also has been investigated and reported upon by the State Board of Health, and by private interests, but it still exists. The Wesleyan epidemic was traced to oysters which were being fattened in a small creek just below a sewer outlet. Typhoid fever was found in a dwelling connected with that sewer. In every case where typhoid fever has been traceable to shell-fish, like conditions have existed, and it is these rare instances of controllable but uncontrolled conditions that are magnified by those seeking an easy notoriety, until they cover the entire field of vision and obscure all else.

Let us look now at the other side of the question. In most of the states in which the shell-fish industry is an important one, except in New York and Connecticut, important efforts have been made, and are being made, toward the protection of these areas from sewage pollution. In the waters of Chesapeake Bay the total pollution is so insignificant in comparison with the enormous tidal prism of that bay that undesirable conditions are practically impossible. Despite this fact the city of Baltimore has spent millions of dollars for safe sewerage, principally for the benefit of the oyster industry. In New Jersey the activities of the State Board of Health have been devoted to the oyster problem for a number of years, with the result that efficient sewage disposal works are ordered or have been placed at practically all points where sewage discharge might threaten an oyster area. In Rhode Island the State Shell-Fish Commission is charged with the duty of seeing that no polluting matter shall be placed in any of the waters of the state where it can reach shell-fish areas. The commission is at present actively engaged in bringing about the enforcement of this law. The sewage of Providence, constituting 75 per cent. of the possible pollution of the Bay from Rhode Island sources, is being effectively disinfected. Unfortunately Rhode Island has no jurisdiction over the city of Fall River and waters immediately adjacent thereto, save to prohibit the taking of oysters in Rhode Island waters that show evidence of pollution. But this last is being done, for all the oyster beds of the state are annually examined and the taking of oysters from uncertified beds is prohibited by law. Massachusetts is not an important oyster state, its principal shell-fish industry being clams.

In addition to these state enterprises, private interests in many cases are doing even more. Expert bacteriologists carefully inspect and test the beds, control the operations of the opening houses, and in many cases regularly analyze the product as it reaches the market. In this way many of the more advanced dealers, realizing the responsibility which rests upon them, are providing virtual guarantees of the character of their product. It is the duty of the consumer to demand these guarantees. This work of safeguarding the health by conservation of food is going on quietly, without advertising, and the public hears little of it.

But by a peculiar perverseness of human nature this side of the subject is deemed an unpopular cause in which to labor. He who would court popularity must proclaim from the house-tops that all things are vile.

Dr. Harvey W. Wiley, writing in *Good Housekeeping*, has recently announced that all the oysters of New York Bay, Narragansett Bay, Chesapeake Bay, and the Potomac River, the waters near Norfolk, the mouth of the James River, the mouths of the Connecticut and Merrimac Rivers, and other industrial streams, and the continental border of Long Island Sound, are open to suspicion, and should not be eaten raw. In other words, he condemns offhand, more than 75 per cent. of the oysters of the eastern market. It would be interesting to know upon what line of reasoning (if any) this opinion is based. For the evidence one seeks in vain. Doctor Wiley complains that his colleagues have more than once called his attention to the fact that they must have "evidence and not expressions

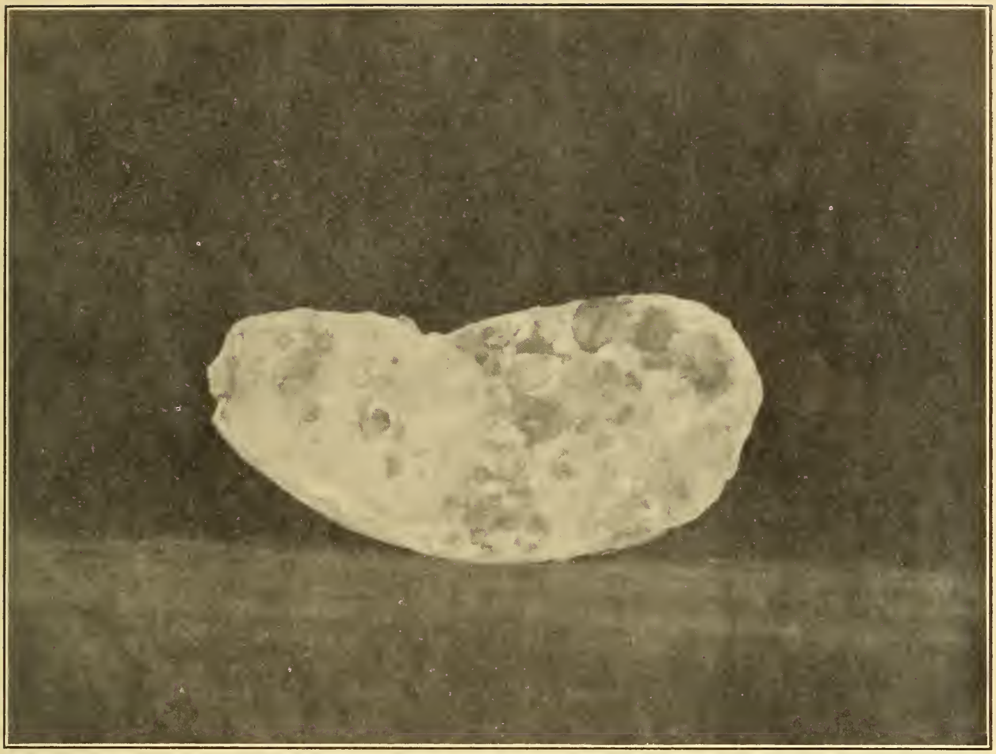


Figure 3. The same "catch" September 12

Figure 4. On September 20 the oysters have developed to marketable "seed." The old shell will rapidly disintegrate

of opinion." At the risk of offending the doctor let us examine the evidence.

The latest report of the Census Bureau dealing with the fisheries covers the year 1908. In that year there were over 33,000,000 bushels of oysters gathered in the United States. Over 75 per cent. of these came from the sources above enumerated that have come under Doctor Wiley's displeasure. Deducting all others and also those oysters taken for seed, there remain enough oysters to provide every man, woman and child in the United States with six oysters per month during the season. Of course there is no such uniform distribution and the great bulk of these oysters are consumed on the eastern seaboard and in the central states. If then the danger is great, one might at least expect to find evidence in the vital statistics of eastern cities, especially where oysters are consumed in quantity. Providence is such a city. Oysters there are cheap and good and are consumed in large quantities by all classes. Dr. C. V. Chapin, Health Officer of Providence, and one of the highest authorities on sanitary science and vital statistics in the United States, has no hesitation in saying that there is no perceptible amount of typhoid fever in his city coming from oysters. The statistics cover those earlier periods in the history of the oyster industry when conditions were far less satisfactory than at present, and when, in fact, almost no attempt was made to prevent the fouling of oyster beds. This opinion is based upon evidence of a most satisfactory character. It is not only shown that the general typhoid rate in Providence is too low to allow for any material influence from oysters, but that there is no geographical distribution of cases corresponding to the known distribution of oyster consumption in the city. The argument is well based upon statistical data and is conclusive so far as Narragansett Bay oysters are concerned. While statistics of this character are lacking in most other places, one who wishes to inform himself may readily enough learn that Narragansett Bay is not specially favored as regards freedom from pollution. The waters of Chesapeake Bay receive much less pollution in proportion to their bulk, and there are bays and inlets too numerous to mention upon the Atlantic seaboard that are far better protected. In fact the points upon the Atlantic Coast from which oysters ought not to be taken are few and insignificant, and oysters from these sources are generally proscribed by the boards of health. Reference has already been made to Jamaica Bay. The waters surrounding New York City are today unfit for oyster culture, and will probably remain so. There are also some points along the Connecticut shore, especially within the harbors, that are badly polluted, and in many cases there are small local sources of contamination, which ought to be looked after by the local health authorities. But the great bodies of water in which 95 per cent. of the oysters now on the market are grown, are free from dangerous contamination and a similar proportion of the oysters of the eastern market may be safely eaten raw.

Doctor Wiley's opinion of oysters, if it have any single basis of fact, must rest upon an interpretation of bacteriological data upon which he is not qualified to pass, and upon which the courts have thus far been obliged to disagree with him. He has been opposed in this matter, and in most of his "opinions," by leading authorities of the various sciences which he has honored with his attention. These gentlemen, many of them scientists of world-wide reputation, therefore become apostles of "suborned science" and "enemies of pure food."

Who then are the friends of pure food; the popular writer and lecturer, who by a word and upon evidence unacceptable to judge, jury or the leading scientists of the world, condemns and would utterly destroy 75 per cent. of the oyster industry of the United States; or that body of scientific men who are devoting their best thought and energy to the problem of conservation of both health and food? The latter are working quietly and with dignity, seeking not notoriety but only the truth. The history of their labors

Figure 5. Three-year-old oyster. The pencil lines show the growth of first and second summers.

finds no place in the sensational press of the day, but is recorded in the proceedings of the learned societies. Their labors are constructive not destructive, conserving not destroying. They attack disease, not food, and stand as the real guardians of the public health.

A DOUBLE DECK STREET CAR

The street railway companies in the cities of Pittsburgh and New York have recently constructed some double-deck street cars. The use of such cars is quite common abroad, but they have not met with favor in the eyes of street railway managers in this country until recently.

The logic of the situation is that it is impracticable to lengthen the present street cars appreciably, or widen them, and the only means then of increasing the capacity of congested lines is to make the cars higher and in two stories. The success of these cars will depend altogether on the attitude which the public takes toward them. L. E. M.

WIRELESS ELECTRIC CLOCKS

One of the newer inventions in connection with wireless transmission of electricity is that of Mgr. Cerebotani of Munich, who has invented an electric clock similar to the well known Western Union clocks, although it differs from them in being regulated by an electric current sent from a wireless sending apparatus. Such a clock evidently may be set up anywhere and if in tune with a master clock will be regulated by it without any of the expensive wiring which is necessary in the familiar forms of electrically regulated clocks. It is worthy of remark that the new receiving clocks will cost not more than $3. L. E. M.

UTILIZING THE NITROGEN OF THE AIR

IMPORTANT CONTRIBUTION OF THE CHEMIST TO THE PROBLEM OF FEEDING FUTURE GENERATIONS AFTER NATURAL FERTILIZATION OF PLANTS HAS CEASED

BY ARTHUR A. NOYES

A German geographer has estimated that the world contains seventeen hundred million people, and that they are increasing at the rate of twelve million a year. During each succeeding decade, therefore, provision must be made for feeding a new population greater than the present population of the United States. This demands an enormous, steadily growing increase in the world's output of agricultural products. How to provide for this increase is one of the largest material problems that confronts our generation and the generations to come. Many factors must contribute to its solution. New land must be brought under cultivation by a wider distribution of population, by increased facilities of transportation, by better utilization of the available water supply through storage and irrigation. A larger yield per acre must be secured by improvement of the varieties of food-yielding plants through biological selection and breeding, through the adoption of more economical methods of farming, and especially through increasing and maintaining the fertility of the land by the scientific use of fertilizers in adequate amount.

This last aspect of the problem is the one with which this article is concerned. It is a vital part of the food problem—one which cannot be eliminated by advances in any of the other directions just referred to; for plants cannot live on water and air alone. They consist, to be sure, in largest proportion, of compounds of carbon, hydrogen, and oxygen; and they have the marvelous power of producing these compounds under the influence of sunlight from the carbon dioxide of the air and the water of the soil. But they contain also as essential constituents certain other elements, especially nitrogen, phosphorus, and potassium, which they cannot obtain from the air,—which they must therefore extract from the soil. These elements are, however, present only in small quantity even in virgin soil; and they soon become exhausted through the harvesting of successive crops. It is therefore necessary, in the long run, to return to the soil the quantities of nitrogen, phosphorus, and potassium that are contained in the vegetable products taken from it.

From what sources then can we obtain these three plant foods cheaply and abundantly? This is so large a question that only one of them, nitrogen, will be here considered. Of the three this is by far the most expensive—by far the most difficult to obtain in sufficient quantity at low cost.

Before discussing the present and prospective sources of supply of useful compounds of this element, it should be mentioned that, though the consumption of these compounds in fertilizers exceeds all other uses of them, yet enormous quantities are required in other industries. Thus, the powerful modern explosives which have made practicable great engineering works, like the Panama Canal and the Hudson River Tunnels, are all nitrogen compounds made by the action of nitric acid on glycerin, cotton, or some other material. Most of the so-called coal-tar products, the artificial dyestuffs, drugs, and perfumes, are also prepared from the substances distilled out of the tar by first treating these substances with nitric acid. Ammonia, too, a compound of nitrogen with hydrogen, is used in large quantity in refrigerating machines and in various chemical industries.

Up to a few years ago there were only two important commercial sources of ni-

trogen-compounds, the great natural deposits of sodium nitrate (the so-called Chili saltpeter) in Chili, Peru, and Bolivia; and the crude ammonium sulfate obtained in the manufacture of gas and coke from coal. But the saltpeter deposits will, at the present rate of exploitation, become exhausted within a period variously estimated at from thirty to one hundred years; and in the meantime, owing to increased cost of production, the price of the saltpeter is steadily rising, thus restricting its availability as a fertilizer. The ammonia produced in gas and coke works is only a by-product, and the quantity of it cannot of course be increased beyond that corresponding to the demand for the main products, gas and coke. The total quantity of ammonia thus produced is in fact entirely insufficient to furnish the nitrogen used in fertilizers; and by far the larger proportion of commercial nitrogen is still derived from the saltpeter deposits of South America.

The nitrogen from these sources costs today in American or European markets not far from fifteen cents a pound—a price which is causing a nitrogen famine among the crops of the world; for the cost is too high to admit of spreading it in adequate quantity over the millions of acres of land under cultivation. This condition of things offers a challenge to the scientific investigator; for, though nitrogen is one of the commonest elements, forming, as it does, four fifths of our atmosphere, yet we are drawing nearly all our nitrogen from South American mines or from gas works and are paying fifteen cents a pound to get it in a form available for plant life!

It might seem as if the problem of converting the nitrogen of the air into compounds that can be assimilated by plants was essentially a chemical one; but recent discoveries have opened also to the biologist a great field of investigation in this direction. For it has been found that, although the higher plants cannot utilize directly the nitrogen of the atmosphere, there are certain common kinds of bacteria, which make their homes on the roots of leguminous plants, such as the pea, bean, and clover, which have the power of absorbing nitrogen from the air and of converting it within the roots of the plant into organic nitrogen compounds.

This discovery explains for the first time the fact long known to farmers that the richness of the soil can be increased by rotation of crops—a fact so extraordinary, till its explanation was understood, that one might well have wondered whether it was not one of the fallacious traditions which are so common among farmers and sailors. This increased fertility is now readily accounted for as follows: Suppose that a crop of wheat is first grown on a piece of land, and that thereby the nitrogen compounds in the soil are largely consumed in producing the nitrogen compounds contained in the grain. Suppose now that the next year the same land is planted with clover. As it grows, the bacteria referred to develop upon its roots, absorb nitrogen from the air, and store up in the roots an abundant supply of nitrogenous compounds. After the clover crop is harvested, these roots decay in the soil and yield up to it their nitrogen content, which becomes available for the nourishment of a new wheat crop during the following year.

An interesting illustration of these considerations has been furnished within recent years by the vegetation of the island of Krakatoa. It will be remembered that this island was overwhelmed in the year 1883 by an eruption of its volcano, which destroyed all vegetation and buried the original soil beneath a thick layer of volcanic ashes. It might have been expected that this new soil of ashes, which was of course free from all nitrogenous organic matter, would not be able to support plant life; yet the island soon became covered with an abundant growth. This vegetation was found, however, to be of an unusual character, in that it consisted very largely of leguminous plants, that is, of those plants which, with the aid of bacteria, can take their nitrogen directly from the air.

These facts suggest that the problem

of supplying plants with the nitrogen needed by them may ultimately be solved most simply and directly by the biologist. For through further study of the conditions determining the activities of different species of nitrogen-absorbing bacteria, considered in relation to the kind of crop, the character of the soil, and other agricultural conditions, it may prove practicable, by inoculating the soil with the proper kind of bacteria and by treating it in such ways as will best regulate bacterial growth, to secure all the needed nitrogen from the air. Already, government agricultural stations are furnishing pure cultures of nitrogen-absorbing bacteria which have a limited value in the case of certain soils.

Until such a perfect solution of the problem can be worked out by the biologist, we shall, however, be dependent on nitrogenous fertilizers; and one of the great tasks of the chemist is to cheapen such fertilizers by obtaining the nitrogen contained in them directly from the air. During the last ten years great progress has been made in this direction; and it remains to describe briefly, without entering into technical details, the general lines along which this problem has been successfully attacked.

Two kinds of processes have been developed. One of these has the object of producing nitric acid, a compound of water with one of the oxides of nitrogen. The other kind of process has for its object the production of ammonia, a compound of nitrogen and hydrogen. For use in a fertilizer the nitric acid, which is a liquid, or the ammonia, which is a gas, must of course be converted into a solid salt. This is most cheaply done by neutralizing the nitric acid with lime or the ammonia with sulfuric acid, yielding calcium nitrate or ammonium sulfate, respectively. Whether the nitrate or the ammonium salt is made the constituent of the fertilizer makes little difference; for, though plants directly assimilate the nitrogen only in the form of nitrate, yet there are always present in soils the so-called nitrifying bacteria whose function it is to convert ammonium compounds into nitrates.

Nitric acid is a compound whose constituents, nitrogen, oxygen, and water, are present in unlimited quantities in the air. The raw materials are available free of cost. The problem is, therefore, only how to make them combine under economic conditions. The difficulty arises from the fact that nitrogen is an extremely stable substance; so that, instead of tending to form compounds with oxygen, the nitrogen oxides tend rather to break down into their elements, nitrogen and oxygen. Thus, scientific investigations have shown that if a mixture of these two gases in the best proportions is exposed to a temperature of 1500° centigrade, that is, to a white heat, only one third of 1 per cent. unites to form nitric oxide, however long the mixture be heated. These investigations have also shown that, while most compounds decompose with rise of temperature, this one, nitric oxide, becomes more stable, the higher the temperature. Thus at 3000° 5 per cent. of the mixture of nitrogen and oxygen will unite to form nitric oxide. To get a fair yield of our product we must, therefore, expose air to an enormously high temperature. But this isn't all; for how can we cool off the gas without causing the nitric oxide which has formed to break up again into nitrogen and oxygen? To do this, we must call to our aid another chemical principle, which is this: although the quantity of a product finally formed in a chemical process sometimes increases and sometimes (as in this case) decreases with falling temperature, yet the *rate* at which that product forms or decomposes always decreases very rapidly as the temperature is lowered. We must, therefore, expose the air to a very high temperature and then very suddenly cool it to a temperature so low that the nitrogen oxide already formed does not decompose at an appreciable rate.

These conditions have been practically realized in only one way—by causing an electric discharge, similar to that in an ordinary arc-lamp, to take place in air. The temperature of the arc is enormously high, but the air just outside of it is comparatively cool; so that any nitrogen

oxide formed at the boundaries of the arc mixes at once with the colder air and thus escapes decomposition. The excess of air containing the oxides of nitrogen is then passed into towers filled with quartz over which water is trickling, whereby nitric acid is formed.

It is not necessary to enter further into details; for these are the essential features of the commercial process for the manufacture of nitric acid which is now being carried out on a large scale at Notodden in Norway. Aside from the cost of installing and maintaining the electrical and absorbing apparatus, the only large expense involved in the process is the cost of power used in producing the electrical discharge. The works must, therefore, be located where water power is obtainable at the lowest possible cost; and Norway was naturally chosen as the seat of the industry in Europe. The saltpeter factories there are already utilizing 200,000 horse-power; and thousands of tons of their product have been shipped to this country, for use in fertilizing the fruit orchards of California and the sugar plantations of Hawaii.

Almost simultaneously with this process for the manufacture of nitrate there is being developed a process for the artificial production of ammonia, its competitor in the fertilizer field. The aim is to produce this compound also from its elementary constituents, nitrogen and hydrogen. Nearly pure nitrogen can now be obtained cheaply from the air by a commercial process which up to twenty years ago had been carried out only on the smallest laboratory scale; namely, by liquefying air with the aid of a liquid-air machine, and then distilling the mixture of nitrogen and oxygen, much as a mixture of alcohol and water is distilled in the rectification of spirit. The nitrogen, having a much lower boiling point, passes off first, yielding a gas containing less than ½ per cent. of oxygen, which can readily be removed from it by chemical means. Pure hydrogen can be obtained cheaply by the decomposition of water in two or three different ways. The raw materials needed for the production of ammonia, although not costless like the air and water used in making nitric acid, are therefore obtainable at low cost; and the main problem again consists in finding a practical way of causing them to combine.

It is a curious fact that difficulties are met with here which are just the reverse of those encountered in the synthesis of nitric acid. Ammonia is a compound on which temperature has the opposite effect: instead of forming in larger proportion as the temperature is raised, it forms in smaller proportion; thus, if a mixture of nitrogen and hydrogen be heated for a long time to 800° centigrade, only one hundredth of one per cent. of ammonia forms, while it can be calculated that at 400° one half of one per cent. of ammonia must finally result. We ought, therefore, to work at as low a temperature as possible; but we then meet the difficulty that the rate of combination becomes extremely slow. Thus, owing to the extreme inertness of nitrogen, no detectable quantity of ammonia is produced, even when nitrogen and hydrogen are heated together for several hours at 400°. When, however, it is known that a chemical change tends to take place in a certain direction and when the only difficulty is that it is going on too slowly, there is always a reasonable hope of overcoming this difficulty; for we know that chemical changes are often greatly accelerated by mere contact with solid substances. Such substances are called catalyzers, and Professor Wilhelm Ostwald, one of Germany's distinguished scientists, predicted a dozen years ago that the great advances in the chemical industries within the next few decades would be made through the more extensive employment of catalytic processes. This prediction has found one of its many fulfilments in the commercial development of the method for the production of ammonia here under consideration. For after many years' investigation certain metals have been found which cause a rapid combination of nitrogen and hydrogen even at comparatively low temperatures. The first metal that was found to have this power in a marked degree was osmium, a metal similar to platinum. As

the total quantity of this element in our possession is estimated to be 200 pounds, and as it is valued at $1,000 a pound, this discovery was hardly a practical one. Later it was found, however, that under special conditions some of the commoner metals, such as uranium, manganese, and even iron, when extremely pure, can be made to serve the purpose. Without entering into further detail, it may be stated that a satisfactory yield of ammonia can be attained by carefully purifying the hydrogen and nitrogen gases, by highly compressing them (up to 50 or 100 atmospheres) and then passing the compressed gases slowly over one of these metals at 500°–600°; and that a large factory for the manufacture of ammonia by this process is now being erected in Germany.

Certain other chemical processes for the fixation of atmospheric nitrogen, less direct than those already described but nevertheless commercially practicable, have also been developed and put into operation within the past ten years. There is, therefore, little doubt that from these sources a large and additional supply of nitrogen compounds will soon be available and that their cost will be gradually lowered. To the vital problem of feeding the human race the chemist is, therefore, making an important contribution.

SWISS AERIAL RAILWAYS

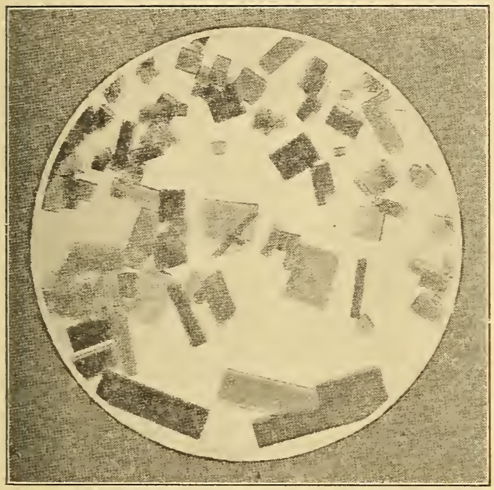
The first aerial railway projected in Switzerland was the work of a German engineer in 1901. The concession was secured in 1904, a company organized, and in 1908 a portion of the road was inaugurated. In the first section the two extremities of the line are separated by a horizontal distance of 1,000 feet, the average incline for the course being 45°.

The line passes over the Grand Glacier that descends the Wetterhorn and at considerable distance from the rocky, precipitous sides of the mountain, nearly to the summit. It is in operation from June 1 to October 1 only, as the heavy snows in the mountains during winter make transportation impracticable and dangerous. The popularity of the Wetterhorn route is handicapped by the fact that the starting point is several miles from Grindelwald, the principal town in the valley, which has no railway connection. Statistics show that 3,000 passengers were carried over the road in 1909, 3,600 in 1910, and 5,000 in 1911.

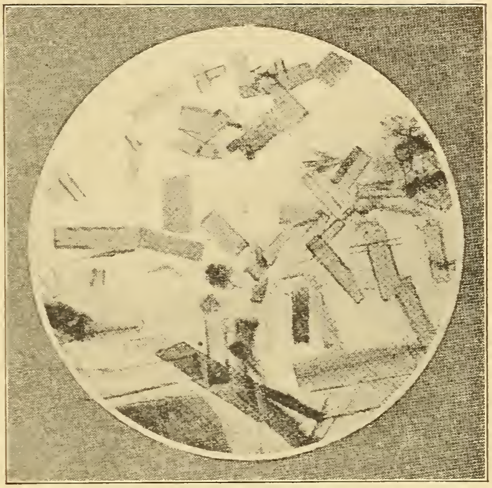
Since the introduction of cable, rack and pinion, and aerial railways in Switzerland, attention of engineers has been directed toward Mount Blanc, the highest peak in Europe and most famous in the Alpine ranges, with the beautifu valley of the Chamonix leading up to its base. On both French and Swiss sides Mount Blanc is comparatively easy of ascent toward the base and not especially abrupt even in the higher regions thus simplifying the problem.

A rack and pinion road has been built and is now in operation from the Valley of Fayet and Chamonix well up on the side of the mountain. From Fayet it ascends to St. Gervais, from where, by an incline road on a grade of 16°, it reaches the Col de Voza at an altitude of 5,500 feet. This road, which is to be supplemented with an aerial line similar to that on the Wetterhorn, is to be extended to Tate Rousse and from there around the sides of the Aiguille de Gouter, from which, through tunnels and galleries, splendid views of the glaciers will be afforded.

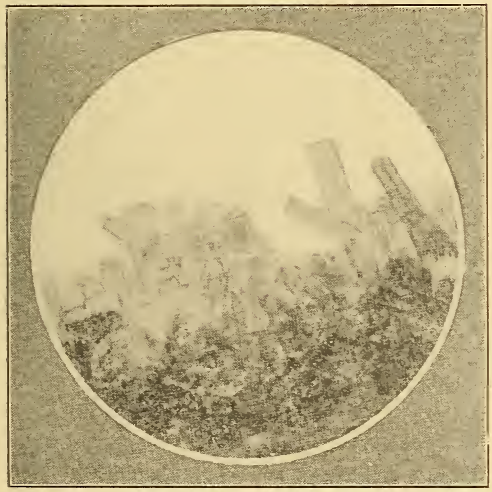
The aerial route will start from the town of Chamonix, at an altitude of 3,000 feet, and will ascend to the Glacier des Bossons at 7,500 feet with two intervening stations. The grade on this section will be 50° to 60°, and the line will finally be extended to the Aiguille du Midi at an altitude of 11,500 feet. The first section is to be completed in 1913 and the extension completed the following year. This road will be worked with three cables—the carrier, the tracteur, and one for the brakes. The carriages will accommodate 24 persons each and are to be supplied with automatic brakes and provided with every possible device for insuring the safety of the passengers.



Blood-Crystals of a Baboon



Blood-Crystals of an Orang-Outang



Blood-Crystals of a Chimpanzee

Blood-Crystals of a Man

HOW BLOOD CRYSTALS DIFFER

THOSE who are not directly connected with microscopie work have, doubtless, often wondered how the human blood can be distinguished microscopically from the blood of simians, or other animals. A new and more delicate test than any heretofore devised has been worked out by two members of the faculty of the University of Pennsylvania. Their test consists in causing the red coloring matter of the blood to form crystals under certain circumstances. These crystals are examined microscopically. By this examination it is possible to tell the difference between not only human and simian blood, but between white and negro. The illustrations show typical blood crystals from the sources indicated.

L. E. M.

WHAT THE ATMOSPHERE IS MADE OF

SIR WILLIAM RAMSAY IN LOWELL INSTITUTE LECTURES GIVES INTIMATE HISTORY OF THE DISCOVERY OF THE GASEOUS COMPONENTS OF AIR

BY JOHN RITCHIE, JR.

If the Lowell Institute lectures on the gases of the atmosphere, by Sir William Ramsay had done nothing more than show to the American public the simple and sterling character of the man and the extraordinary wealth of resource in expedient at his command, they would have been well worth the giving. But they did much more, for besides the academic story of discoveries that have made their mark upon the chemical world, there was the constant running fire of comment by one intimate with every detail in the long and complicated processes. How interesting, for example, in the naming of neon, to learn that it was the young son of Sir William, home on a vacation from school, who strolling into the laboratory learned of the discovery of the gas. "And is it truly new?" he queried, and on being assured that it was, he said, "Why not call it Novum?" The Latin terminology was, however, not of the customary order, so the Greek was called into requisition and "Neon" it became.

The lecturer took to his country most of the credit for discoveries with reference to the atmosphere, noting that Britain is proverbially ruler of the seas; that she, in the opinion of many is acquiring too great dominion over the land and in the third element, air, "all but one of the important [chemical] discoveries were made by Englishmen."

In his introductory lecture Sir William gave a short history of the chemistry of air and displayed in it some of his philological lore, telling his hearers that gas and ghost are kindred words, gust being another relative, indicative of the fancied relations between air and the spirit or life. "Gas is a made word," said the lecturer, "and is common to modern languages, while another such manufacture, 'blast' was coined in expression of the life of the stars. But since stars have no life from man's point of view, it has not come into familiar use."

The historical story was a very interesting one, pivoting on the old "phlogiston," which became a catch-all for the explanation of obscure phenomena. Phlogiston was that which substances lost in various processes of burning. The scum of melted lead—now known to be lead oxide—was made by phlogiston and if removed the lead was dephlogisticated. Air might likewise be dephlogisticated, and as this material was added or removed the intricate phenomena resulted.

The four elements of the ancients, fire, water, earth and air, with contrasted qualities, individually and in pairs, persisted till the fifteenth or sixteenth centuries. Earth was cold and dry; air, hot and moist; water, cold and wet, and fire, hot and dry. Boyle in the early sixteen hundreds; Mayow, born during the life of Boyle, but quiet and practically unnoticed and Stephen Hales, worked each diligently as chemists, considering all gases to be air and having no other notion. Mayow found out that air has "nitro-aëreal particles" and "mephitic," and Hales discovered that a great deal of gas can be derived from small quantities of solids. He distilled many things in his laboratory, including what are modern products; he saw that air is a chaos of elastic and inelastic things, but he failed to catch the import of his discoveries. Thus far everything had been hypothetical, there was no standard used and phlogiston was ready at every turn to account for strange results.

Joseph Black was the first real discoverer; he brought into requisition delicate scales, and came upon the idea of

changed chemical condition later developed into "conservation of matter." An experiment with magnesia was repeated by the lecturer in much the same form as worked by Black, in which after decomposition, the magnesia was reconstructed. Black's pupil, Rutherford, born in 1749, took for his thesis the qualities of a cold, fixed air, which was really an investigation into the nature of the residual gases after certain kinds of experiment.

It was Priestly, born in 1733, who discovered oxygen, and he had such confidence in its life-giving qualities that he inhaled it, looking forward to the time when others might avail themselves of the luxury, "which till now has been enjoyed only by two mice and myself." Then came Lavoisier, who first mentions nitrogen under the name it still has with the French, azote, he determining that there are four kinds of air, common air, pure air, which is indeed oxygen, azotic gas and fixed air, which is carbonic acid gas. He had really the mystery of the air within his grasp, and produced hydrogen from water, but in the very last of his many memoirs defended phlogiston.

The general historical story ended with Cavendish, quiet and retiring, almost unknown save in very limited circles, who discovered the composition of water. He maintained the idea of phlogiston although the lecturer showed that he did so from the desire to speak to his contemporaries in current phraseology rather than on account of belief in it. He did question to himself the validity of this curious substance and, had he used the chemical balance in his experiments, would undoubtedly have discarded it altogether. He plainly states that where there is phlogiston there is always water and suggests that it may be the water that is effective. He worked largely for his own pleasure and was not quick to make public his discoveries. He did accomplish, however, most remarkable things, some of them in other fields. He accumulated facts which were accurate quantitatively; for example, that there is 1–120 of the air that will not combine, a figure that today, one hundred and thirty-five years later, is set at 1–84. He computed the density of the earth arriving at the figure, 5.4 with water for the standard, and more than a century of observation, measurement and computation has changed only the decimal places, the accepted constant being now 5.5777.

The work that this man did was wonderful whether taken in quantity or quality. He worked a great deal with the air, he analyzed it for sixty days and in many places, he showed its constant composition and really paved the way for the discovery of argon. One series of experiments was made to find out when a quantity of air was diminished by phlogistication, where the missing air went to.

How argon came to be discovered was one of the most charming of the series of lectures for here Sir William Ramsay spoke of his relations with Lord Rayleigh and drew a pen picture of this distinguished and broad minded investigator, whose experiments in determining the relative weights of oxygen and hydrogen led first to publications from 1882 till 1893, the last year seeing a comparison between oxygen and nitrogen; next to the request to the members of the Royal Academy for suggestions, and last, to a meeting with Ramsay. Rayleigh had been working out the comparative densities of the gases and to check his observations he made use of gas produced in a number of different ways. He had oxygen from three different sources and found an agreement in the weights between them, but nitrogen when derived from ammonia he found to be lighter than when taken from the atmosphere.

At this juncture Ramsay suggested to Lord Rayleigh that the repetition of some of Cavendish's old experiments might give a clue to the mystery, and Rayleigh said, "Try it out yourself." The experiments, which were repeated on the platform, developed a method of consuming the nitrogen from ordinary air. The oxygen was first removed, then any traces of water and then again a trap was laid for any remaining oxygen. The nitrogen that was left was forced through chips of magnesium and was more or less consumed. At first there was a simple device for

returning the nitrogen again and again to the magnesium and later automatic methods were devised which would effect this end till it was consumed. Means of testing were always possible and the speaker showed how in the successive devices there were improvements. It was evident after a while that there was an unconsumed residue, and this was argon.

Incidentally the lecturer told that he had taken magnesium for the selective material from the fact that in the old experiment when it was burned in a close crucible there was the odor of ammonia showing combination with the nitrogen of the air. In the later experiments, a mixture of lime and magnesium has been substituted for the magnesium chips. He noted that when the experiments were under way the announcement of the offering of the prize from the Hodgkins fund in the possession of the Smithsonian Institution was made. He spoke of this to Lord Rayleigh, suggesting to him to try for it, but the latter would do nothing by himself and made Ramsay take common cause with him.

In August, 1894, the announcement of the discovery of the new gas was made to the British Association. Sir Oliver Lodge was present and said, "These young men have discovered something that is new; have they also discovered its name?" A name was therefore sought, and since the gas was inert, the text, "Why stand ye here all the day idle?" was suggested. Argon is the neuter of the Greek word, idle, in this phrase.

The argon story of Sir William Ramsay, quietly and modestly told, was a key to the supreme scientific character of this leader in chemistry, for it showed his resources as well as his patient care and industry in trying thousands of experiments and one could see the acute inventive mind working all the time to evolve new processes or simplify and perfect those already known.

One fact that puzzled the discoverers of argon was the fact that its spectrum was subject to variations, and these were so curious that it was suggested that here might be a triad of gases and the names, Anglium, Scotium and Hibernium were even suggested for them. But the investigators worked on trying for results instead of anticipating them by processes of guessing. How to get more argon, how best to produce it and with what substances would it combine were the lines of research. First of all, typical animal and vegetable sources were tested to see, of course, whether some substance richer in argon than the atmosphere could be found. Mineral waters were also tried and it was finally concluded that argon is a component not of the atmosphere alone but is contained in various earthy products.

With reference to the combination of argon with other substances, the possible range was carefully tried out. The speaker named a score of active agents to which it was inert, the line was passed where gold is no longer resistant to change and then the limit for platinum. Argon was not affected by electric sparking nor by fluorine, which is of great activity in making combinations. Then the fierce energy of the electric arc was tried and at the other end of the thermal scale, liquid air. From all of these tests argon emerged unchanged and undiminished and the distinguished lecturer said, in concluding this part of his series of topics, "It may be possible to make a combination with argon, but in the light of knowledge today it is difficult to see how it can be done." The making of argon was one of the experiments of the evening of this lecture.

The story of helium was begun by Sir William at a number of different points. First there was related an outline of what was done by Doctor Hillebrand of the United States Geological Survey, who in heating some of the compounds of uranium—a rare element—found a gas whose spectrum was unknown to him. Janssen, the great French astronomer, during the solar eclipse in India, obtained with the comparatively new spectroscope a spectrum having a bright yellow line. The great English spectroscopists tried to place this and finally the world came to the realization that it was a new gas and it was named helium. Sir William Ramsay secured from Doctor Hillebrand some

specimens of his mineral, cleveite, for experiment and soon saw that the spectrum was not that of sodium which also has a bright yellow line. Taking it to Sir William Crookes, who was better fitted out with spectroscopic apparatus, the latter viewed the spectrum and pronounced it to be that of helium, then first identified from earthly materials. The next thing, of course, was to find out by what it could be produced in larger quantities. "The proverbial needle in the haymow was simplicity itself," said the lecturer, "compared with this task," and the outlining of what was done in the research is testimony to the splendid resources of the great Englishman, or rather Scotchman. The British Museum was ransacked for minerals and about two hundred likely samples were taken. These were subjected to tests, but no new spectrum resulted; then the gases of mineral waters were tried and even the volcanic gases of Iceland, to which country Sir William journeyed on his quest. Meteorites were heated and a great range of such experiments tried, but all without avail. "And all this time," said the lecturer, "it was all about us in the commonest thing we had, the air." This was in 1896 and the means which were to put the great results into the hands of the investigators were just coming into reach of scientific men. This was liquid air, and by way of return for courtesies of the laboratory the first litre of this product made by an Englishman in a new way was sent to Sir William. The relation of this to the discovery was that cocoanut charcoal has an extraordinary appetite for gas and the colder it becomes the more gas it will absorb. Charcoal chilled to the very low figure of the temperature of liquid air does select from mixtures of gases in contact with it all of those then known to be in the air excepting helium. This gas was not absorbed in such processes and the scientists collected it in sufficient quantity for the determination of its various chemical constants.

Gaps in the rhythmic order of qualities as shown by the tabulations of chemical elements furnished the suggestion that there were missing elements and the low temperatures of liquid air and hydrogen furnished a means of separating them from their companions. In a rough way the process may be explained by the different temperatures at which the different gases liquefy or freeze. One gas will become liquid while another is still a gas, or freeze while its companion is a liquid. The gas can be pumped out or the liquid drawn off, while the second gas remains in different condition.

The litre of liquid air that was received by Sir William was used largely for amusement, the scientists literally playing with the strange, new material. When it was nearly all gone, scientific tests were suggested and the familiar treatments were given it. It was found that the residue had a higher weight than the normal one of argon. From this circumstance there came the separation of krypton, so called because it had been hidden.

Of course with the increasing ease with which liquid air could be obtained such experiments were repeated and it was noticed that even with the krypton taken out, there was always a bubble of residue. This was tested in the ways known to chemists; the spectrum showed that it was still a different gas and xenon, the stranger, was produced. It was the separation of the gases by means of their different vaporizing points that was now used in the discoveries. Xenon proved to be the heaviest gas then known, sixty-six times the weight of hydrogen.

At this time, in 1898, the business of liquefying air assumed relatively great magnitude, and the investigators in London were able to acquire a considerable quantity—fifteen litres— of argon. This was treated in the various ways that had been evolved in previous experiments and from it was produced or rather separated a light gas with red spectrum. This was neon. Still more recently through the ability to get larger quantities of argon, it has been possible to gather as much as 120 cubic centimetres of neon. This has been tested in all the ways known to chemistry of today to determine whether still other gases are in combination with it, but it has resisted separation so that

the discussion in this direction seems to be finished.

Although it would seem as if here would be the end of the story of gases in the atmosphere, the final lecture brought out the fact that still another remained, which in due sequence of investigation and discoveries, was found and its characters determined. This was niton, so-called because when frozen it shines. The story was one that took up the investigations in the matter of radio-activity. It is known that electricity may be gathered high in the air and its source was always a mystery. It is now known that it is formed by the decomposition of the gases. The radio-activity story led up to the showing that there is a radium emanation which has certain peculiarities and relationships in a curious group of activities. This is now known to be a gas and a constituent of air. Its presence was suspected at last through a gap in the chemical tabulation of elements. Hydrogen was suspected of being possibly in combination with something; the temperature of the combination was lowered; there was a process of solidification at a temperature at which hydrogen was still unfrozen, the latter was pumped out and the residue examined. Thus the gas niton was found, an unstable one, it would seem, for the members of the radium group of substances are continually parting with atoms or electrons and becoming other members of the group. Helium and electrons are alternates in this loss, which is a phenomenon giving rise to new concepts in chemistry.

MECHANICAL CANAL LIFTS

On the branch canal connecting the Brussell-Charleroi route with the Canal du Centre between Seneffe and Houdeng in Belgium, there is a difference in elevation of about two hundred ninety-five feet in fifteen miles with the further complication of a lack of water supply in the upper reaches. It has become necessary to use four mechanical lifts which together accomplish a rise of two hundred eighteen feet, each lift overcoming from fifty to fifty-six feet difference in elevation. These lifts consist of pairs of steel chambers, nineteen by one hundred forty feet and ten feet deep, supported on hydraulic plungers. The two chambers of a lift move in opposite directions, simultaneously raising and lowering a 360-ton barge on the two sides.

EROSION BY RAINFALL

The United States Geological Survey is responsible for the statement that the surface of the United States is being removed at a rate of thirteen ten-thousandths of an inch a year or one inch in seven hundred and sixty years. This means that two hundred and seventy million tons of dissolved matter and five hundred and thirteen million tons of suspended matter are transported to tide water every year by the streams of the United States.

This total of 783,000,000 tons represents more than 350,000,000 cubic yards of rock substance, or 610,000,000 cubic yards of surface soil. If this erosive action had been concentrated upon the Isthmus of Panama at the time of American occupation, it would have excavated the prism for an 85-foot level canal in about 73 days. The amounts removed from different drainage basins show interesting comparisons. In respect to dissolved matter, the southern Pacific basin heads the list with 177 tons per square mile per year, the northern Atlantic basin being next with 130 tons. The rate for the Hudson Bay basin, 28 tons, is lowest; that for the Colorado and western Gulf of Mexico basins is somewhat higher. The denudation estimates for the southern Atlantic basin correspond very closely to those for the entire United States. The amounts are generally lowest for streams in the arid and semiarid regions, because large areas there contribute little or nothing to the run-off. The southern Pacific basin is an important exception to this general rule, presumably because of the extensive practise of irrigation in that area. The amounts are highest in regions of high rainfall.

PROGRESS IN A PUZZLING MALADY

HOW THE STABLE FLY HAS PROBABLY BEEN RELATED TO INFANTILE PARALYSIS—STORY OF AN INTERESTING RESEARCH IN MASSACHUSETTS

BY CHARLES T, BRUES

The fact that several common human diseases are spread through the agency of blood-sucking insects is now quite familiar to the general public; in spite of the very short space of time which has elapsed since any disease was shown to be specifically insect-borne.

Nevertheless it is difficult to realize that scarcely more than a decade separates the present from the time when yellow fever and malaria were removed from the category of mysterious maladies whose method of spread was utterly unknown. These, together with splenetic or "Texas" fever of cattle formed a nucleus about which has been grouped a number of other human and animal diseases all of which are transmitted by specific insects or closely related animals. Certain mosquitoes, blood-sucking flies, ticks, lice and bugs have thus been shown to be concerned in the spread of disease and their pernicious activities have been carefully investigated from the standpoint of public health.

The most recent addition to the category of insect-borne diseases is anterior poliomyelitis or acute epidemic poliomyelitis, more commonly known as infantile paralysis.

Stable Fly (Stomoxys Calcitrans) loaned by Dr. Sheppard for Photographic Reproduction

During the past several years a suspicion has been developing among students of this disease that it, too, might result from infection carried by some insect, and the Massachusetts State Board of Health decided to have this possibility investigated during the summer of 1911, under the direction of Dr. Mark W. Richardson, the secretary of the board. Accordingly, as entomologist, the present writer in company with Dr. Philip A. E. Sheppard, who was investigating for the State health authorities the epidemiology of the disease, attempted to determine by observation in the field, whether any special insects might appear to be associated with the cases which occurred that season in eastern Massachusetts. Working in this way, it was possible to eliminate many insects which might otherwise have been suspected as carriers, and as the season's work progressed the suspicion gradually

grew more and more strong that the common stable fly (*Stomoxys calcitrans*) might be the insect concerned, especially as the seasonal history, distribution and habits of this blood-sucking fly appeared to fit in closely with the observed epidemiology of the disease.[1]

During the past summer of 1912 Prof. M. J. Rosenau of the Harvard Medical School, who was already thoroughly familiar with the disease, and the present writer, undertook to determine experimentally with monkeys, whether the stable fly could act as a vector for the virus of poliomyelitis. The successful outcome of this work has very recently been announced in a paper [2] describing the experiments in which healthy monkeys developed poliomyelitis after having been bitten by stable flies which had previously fed upon the blood of monkeys infected with the disease. These results have been further confirmed by Drs. Anderson and Frost of the Public Health and Marine Hospital Service,[3] who repeated the same experiments and definitely proved that the disease develops in monkeys which have been bitten by stable flies that have previously fed on monkeys suffering from poliomyelitis.

The stable fly is a small insect very much like the ordinary house fly, to which it is closely related, and for which it is frequently mistaken on account of its size, rather similar coloration and common occurrence in the neighborhood of human habitations. In spite of its close similarity to the house fly, it differs in a number of important respects, both in structure, habits and distribution, and on account of its recently discovered relation to human welfare, it is worth while to mention these briefly.

The adult flies feed exclusively on blood, biting various animals and less commonly, but nevertheless quite frequently, biting persons upon parts of the body where the skin is exposed, or where the clothing is thin. Among domestic animals they occur most commonly on cattle and horses which are often much annoyed by them during the later part of the summer. On account of their feeding habits, the flies are more common in rural districts where the number of animals is large, or in the case of more thickly populated districts, in the neighborhood of stables or places where large domestic animals are most numerous. It is difficult, however, to find any locality of any considerable extent under ordinary conditions where this fly does not occur. Although the flies are found in the vicinity of dwellings, they do not enter homes so commonly as does the ordinary house fly, but rather prefer to remain in the open and more especially in sunny places unless attracted elsewhere by animals or persons. Their normal food consists of mammalian blood and during its lifetime each fly feeds every two or three days, perhaps oftener, upon some warm-blooded animal, less commonly biting human beings. In fact this insect has given rise to the adage that house flies bite before a rain, which is based on the fact that persons are frequently bitten at such times by Stomoxys, which are then apt to come indoors and are mistaken for the house fly. The latter cannot pierce the skin, however, with its soft, blunt mouthparts, while Stomoxys can readily insert its needle-like proboscis into the flesh. In the writer's experience, however, Stomoxys seems to have more commonly bitten on warm, bright days, although he has been bitten even at night while writing near an electric light. Other observers have noticed that the flies often seek shelter at night. Both sexes are blood-suckers, and become greatly swollen when allowed to feed unmolested.

[1] Brues, C. T., and P. A. E. Sheppard. The Possible Etiological Relation of Certain Biting Insects to the Spread of Acute Epidemic Poliomyelitis. Bull. Mass. St. Bd. Health, December, 1911, pp. 46–48 (abstract); Journ. Econ. Entomology, Vol. 5, pp. 305–324, August, 1912 (full report).

[2] Rosenau, M. J., and C. T. Brues. Some Experimental Observations upon Monkeys Concerning the Transmission of Poliomyelitis through the Agency of *Stomoxys calcitrans*. Bull. Mass. St. Bd. Health, Sept., 1912, pp. 314–317.

[3] Anderson, J. F. and W. H. Frost. Transmission of Poliomyelitis by Means of the Stable Fly (*Stomoxys calcitrans*). Public Health Reports, Vol. 27, No. 43, pp. 1733–1735 (October 25, 1912).

When thus engorged they remain sluggish for a time and are apt to rest with the wings somewhat more widely spread apart than the house fly, and with the body more distinctly elevated, assuming a more sprightly attitude.

If one of the flies is examined closely from above as it rests thus, the proboscis can be seen projecting horizontally like the tip of a fine black pin directly forward from the lower edge of the head. Viewed from the side, the proboscis is seen to emerge from the lower side of the head and then bend forward at right angles for a distance about the height of the head. When sucking blood, the proboscis is straightened so that it projects directly downward from its attachment to the head. In the resting house fly the mouthparts never project forward so as to be visible from above, and this difference will always serve to distinguish the two species at a glance.

Stomoxys appears early in the spring, but becomes much more abundant after midsummer and persists in numbers late into the fall, after the house fly has begun rapidly to disappear.

The breeding habits are much like those of the house fly. The eggs are deposited in small masses; the individual eggs are long, slender, minute objects of a pearly white color. Each hatches into a minute white maggot, slender at the head and enlarging behind to a blunt posterior end. The maggot or larva feeds rapidly, increasing in size and molting twice before changing into the pupa or resting stage from which the adult fly will emerge four or five weeks after the egg has been laid. The pupa is enclosed in an oval brown shell or puparium which is broken open at the head end to afford an exit for the emerging adult fly at the termination of the pupal stage.

The eggs are laid directly upon the materials which will serve as food for the larva. Fermenting heaps of grass, straw and similar substances, horse manure cow dung and even garbage may serve as breeding places. The relative importance of these different foods is not yet very well known, but it seems probable that this is about in the order named. Excessive moisture is also particularly favorable for the development of the larvæ.

Stomoxys calcitrans is very widely distributed over the earth, occurring abundantly throughout Europe, North and South America, the West Indies, northern Africa, Asia, Australia, etc. It is the only member of its genus in the New World, but has a number of close relatives in the tropics of the eastern hemisphere. Whether it is native to North America or is an importation from the Old World is difficult to say, but from its wide occurrence, one would be perhaps inclined to think it native to our own region. At any rate it has been in America for a long period.

The control of *Stomoxys* will probably prove as difficult as that of the house fly and its eradication is obviously impossible. The ordinary flytraps and sticky flypapers which have proved so useful in dealing with the house fly are of no practical benefit in combating *Stomoxys* since it is not attracted to the resinous coating of the paper nor to the baits used in fly traps; as its only food in the adult condition is the blood of living animals, it is attracted only to such and cannot therefore be caught in traps. However, the "coming and going" flytraps devised by Professor Hodge will undoubtedly catch large numbers of *Stomoxys* if attached to the doors and windows of stables and barns. The most important method of control must undoubtedly depend upon the fact that the species develops in manure, decaying grass cuttings, etc. The proper handling of these is a difficult matter but can unquestionably be solved and will aid materially in abating the house fly nuisance as well.

Editorial Note:—It is interesting to note the origin of Brues-Sheppard hypothesis of transmission by fly bites. During his investigations of 1910 and early in 1911 Doctor Sheppard had been repeatedly told of fly bites in the history of the cases of infantile paralysis. It was only when Mr. Brues, a skilled entomologist, was selected to work with him in

the matter that the particular fly was found. The two men found together in Southboro in August, 1911, that in a family of six children and two adults, all the children were affected, one having been affected also sixteen years before. Two deaths occurred there. The types of disease varied from a slight involvement of the muscle to a fatal paralysis.

Stomoxys was found in great numbers about the barn, on the cattle and about the house distant one hundred yards from the barn. It was even in the chambers of the house where the sick members of the family were lying. Doctor Sheppard noticed that the flies in the latter room were filled with blood, presumably taken from the human cases.

The conclusion was reached that there is good reason to suppose that mature Stomoxys will carry the organism from one human sick person to another individual by means of its bite. This was the basis of the experiments. It is still to be shown, however, whether this transmission is merely mechanical or that a definite period of incubation is necessary in the fly before it can give the infection; whether the fly can give infection at once on biting some other person, or whether definite time must ensue before Stomoxys is able to infect.

There will be some further question in the matter as to persistence of the virus in recovered humans. In the Southboro family the girl of nineteen years, who had an attack long before, was upset by some gastro-intestinal difficulty. There is here the question whether with her balance upset she may not have been the origin of the other infections in the family.

PROTECTING PANAMA CANAL GATES

A recent article in *The Engineering Record* describes many accidents which have happened to canal lock gates, both here and in Europe, due to a variety of causes which have been taken into consideration by the engineers of the Panama Canal. By way of precaution the following safeguards will be employed:—

Vessels will not be allowed to approach the locks under their own steam, but will be towed through long approaches at both ends and through the locks by one or more locomotives on each side of the canal. Other locomotives in the rear will keep the vessels under balanced control. At each end of the locks will be a pair of guard gates, exact duplicates of the operating gates and 60 or 80 ft. distant from them. Finally the gates will be protected by an exterior barrier consisting of a horizontal transverse chain with a breaking strength of about 250 tons. The ends of the chains will be attached to the plungers of hydraulic cylinders so that the chains will operate as automatic buffers to receive the impact of a vessel, which, as it presses against the chain, gradually develops increasing pressure in the cylinders until it has absorbed a large amount of the energy of the moving vessel and the automatic valve opens under a load about equal to the breaking strength of the chain. The chain will be lowered to the bottom of the canal to permit the passage of ships under control. With these safeguards and movable dams to close the canal above and below the lock all contingencies seem to be well provided for.

PROMPT TELEPHONE SERVICE

Those of us who have experienced the exasperation of waiting impatiently for an answer to our call may take unction unto our souls from certain statements made by a writer in *Popular Electricity*. In London, observations were made upon 50,000 different calls, and it was found that the time taken for a call, including the time of ringing up and the time of the operator answering the call, was on an average of 5.1 seconds. The time needed for making the whole connection was 28.6 seconds. A similar record, covering over 55,000 calls made in Chicago during 1911, gave the average time taken for the operator to answer a call as 3.1 seconds. The time necessary to make the whole connection which covered the time up to the time the subscriber answered was 25.4 seconds. L. E. M.

HORSE, GASOLENE AND ELECTRIC TRUCKS

INVESTIGATION OF THEIR RELATIVE EFFICIENCY MADE BY THE DEPARTMENT OF ELECTRICAL ENGINEERING OF THE INSTITUTE OF TECHNOLOGY

THE Massachusetts Institute of Technology has been giving, the past two years, an example of its methods in the investigation of live business problems, by a determination of the various elements of cost in using motor trucks. It is really a pioneer work, for till now the determinations of the motors' efficiency have come generally from the car manufacturers and hence have been always liable to discussion if not to the suggestion of bias. But with the standards determined by an institution like Technology such an objection is no longer to be urged.

The enormous growth of the motor vehicle industry—a larger number having been sold last year than in all the preceding years—makes certain standards necessary and the business men themselves saw the need and turned to the department of electrical engineering of the Institute for its solution. Funds, including one to care for the main portion of the work from the Edison Electric Illuminating Company, and other contributions like that of $1,000 from Thomas A. Edison, for the discussion of special features of the problems, have been given the department.

The research was entered into in a very broad way. It took up the matter of comparative cost and efficiency of horse-drawn, gasolene and electric trucks; it considered light and heavy loads and it observed the needs of all kinds of teaming from the delivery of department store parcels to the moving of the heaviest freight from terminal to terminal. It has investigated the conditions of freight yards and sought to determine the causes of delay, if any, and one of the future problems to be considered is that of effect of kind of paving on cost of teaming.

What may be the advantages of one kind of truck over another is a matter in which, up to the time of this investigation, there has been very little information. The procedure was first to analyze the services and to determine relations between each kind of truck and the work it is expected to perform. This was done largely by means of the "clocks" of the Boston Delivery Supervision Company, who aided in maintaining the registers and in other details. The clock marks on a tape the performance of the truck to which it is attached, showing how long the wagon is at work, at what speed it travels and how long it rests. The register has been fancifully termed in the West "the machine that counts the driver's drinks." Records from such registers to the number of sixty a day were received at the Institute during last winter, spring, and summer and analyses made of their readings. It may be seen that from such data the cost factors may be determined. It is possible to set apart what the cost is to the teamster of congested streets, inadequate loading or unloading facilities and other matters hitherto only to be roughly estimated.

In the investigation one of the first items to make itself apparent was the limitations of possible work. A horse-drawn truck carrying two tons can be counted on in city streets for a maximum of fifteen miles, while an electric truck in the same work can make thirty-five miles. To do a day's work the horses must keep moving four hours during the time and the motor truck must run five and one-half hours. There is little gain in a nine-hour day in reducing the standing time of the horses to less than 55 per cent. of the whole time, while the motor truck must not stand still more than 45 per cent. of the time.

It is possible, therefore, to name conditions under which the horse-drawn vehicle will be more economical. It is

true that motor trucks have great advantages in rapidity of movement and radius of action over the horse, but at the same time proportions of cost are very important in business. If the cost of hauling merchandise should be very small in proportion to other costs, the matter of a few cents a ton for haulage may really be secondary to such items as reliability and punctuality.

The first important result of the research is here, therefore, that every class of service must be considered by itself, and there can be no general uniform rule. The merchant must base his selection of the kind of vehicle on the requirements of his business.

Some of the preliminary estimates will serve to show the nature of the investigation and its relations to most efficient conduct of this portion of the business. In parcel delivery with a nine-hour day, three trips, four parcels delivered per mile and one minute consumed in each delivery, three-quarters of an hour being allowed for loading and the maximum load being half a ton, the horse-drawn wagon does two thirds as much work a day as either the electric or the gasolene truck and the costs per parcel are 5.4 cents for electric, 5.9 cents for horse and 6.5 cents for gasolene, respectively. The cost per mile for the horse is likewise between the other two costs. In the delivery of coal, which is at the other extreme from parcels, being in large lots and to a single place, with loads of five tons, the horse wagon (three horses, one resting every third day) does about half as much work as either of the motor trucks. The cost of delivery per mile is 47 cents (electric), 55 cents (horse) and 58 cents (gasolene), while the cost per delivery of the whole load is $3.32, $3.91 and $4.07, respectively.

The foregoing estimates are not given as comparisons of the economic fields of electric and gasolene machines, but as the relative performance in services whose hauls are of moderate length.

If, however, it is a requirement in a parcel delivery that two minutes be required by each delivery instead of one there is an increase in the standing time, a reduction in the mileage per day and the cost of delivery is raised to a degree that is surprising. For the horse the increase is 22 per cent.; in the gasolene truck, 30 per cent.; while in the electric vehicle it is 27 per cent. This shows how the introduction of what may seem to be a minor variation may really change considerably the cost relationships.

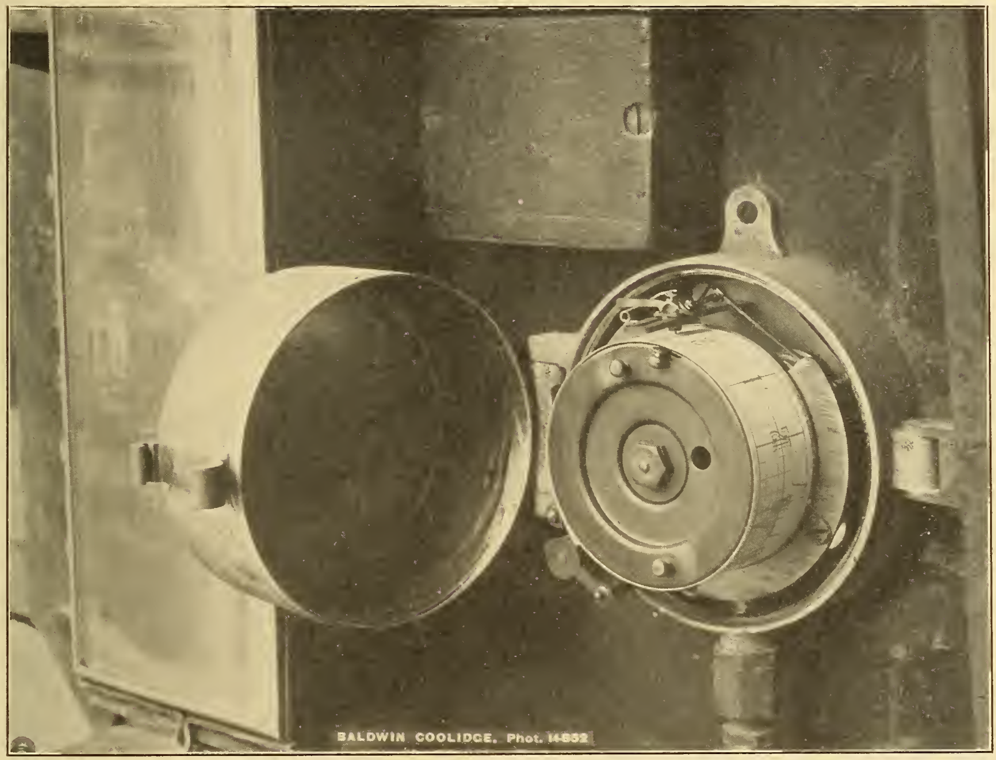
In the matter of total expense the horse cost is again between that of the electric and gasolene trucks.

One of the important matters developed in the research is the lack of uniformity in accounting, which has in the past obscured the real relations between cost and service. It was found that according to the practices of different firms, the drivers' wages were omitted from the operating costs in some cases, and in others rent of garage, while pretty generally items like insurance and taxes were not charged to the trucking and seldom depreciation and the costs of administration.

In connection with the work the investigations were carried on in freight yards and other places said to be congested. In freight receipt and delivery there were considered as separate factors such things as entering, waiting, backing, loading or unloading and going out.

Backing turns out to be a time-consuming operation so far as horses are concerned, for a one-horse wagon requires one and one-half times as long to back to its loading or unloading position as a motor truck; the two-horse wagon twice as long and the four-horse hitch two and one-third times as long. In congested places the motors have another advantage, for the horses occupy valuable space and the motors can work in and out better through moving traffic.

These items are practically the work to March, 1912. Since that date, with renewed support by the Edison company and other contributions the work has been continued by the department of electrical engineering of the Institute as before. The field of observation has been enlarged and other cities have been included in the group from which cost data are received, among them



Register on a large electric truck, taken at 2.30 P.M. Time is shown by the figures; it is a mile from the central line to the edge and the slant lines are the work record. The truck rested from 11.15 till 1.10, made over two miles in one run, rested five minutes and did another two miles, and had been resting half-an-hour when the picture was taken.

New York, Philadelphia, Washington, Chicago, Detroit and Saint Louis together with some of the smaller places. Not only have the automatic registers been used but men have been employed to check the results and there has been a closer personal contact with the superintendents of large garages and the users of individual trucks.

Other difficulties in considering the problems, which have heretofore been done by firms or individuals with a commercial interest in the results, have been very apparent in the last year of the work. There are not as yet any reliable checks or many real standards. The manufacturers usually have a guarantee—a stated mileage for the tires, for example—but abuse by the driver or other items of roads and grades may cause failure to attain the standard. Generally there is a compromise reached that makes the real cost larger than the manufacturers' estimates. The book figures may be misleading. For example if a truck should run 14,000 miles in a year, with tires worn out at the end of 8,000 miles, the books would show only the cost of one set, whereas the second set would be three quarters gone. Of course this would be averaged in a number of years, but would require for it three or four times as long as most firms have as yet owned their trucks. In fact there is here one of the present difficulties, that the automobile truck has not yet been long enough in use for standard figures to be established with reference to its durability. So little is known about this that the figure for depreciation, if any

note is taken in the matter, is as yet a rough estimate.

The estimation of repairs is even more difficult than that of tires, for here the road-surfaces, climate, nature of the care, etc., all enter into the question. When it comes to battery renewals there are other complications and not only is the mileage to be considered, but the number of stops in addition to road conditions and care. Then there is the different cost of electricity in different places and the fact that the price of gasolene varies from that used in the estimates. These suggestions will show how carefully the Institute experts have gone into the matter.

The second of the bulletins on the cost of motor trucking by the department, reporting progress to October, 1912, consists largely of tables and diagrams of cost data which had been collected from operators of cars. In tire renewals for electric trucks the highest cost was found to be in the heavy trucks and here it ran as high as 11 or 12 cents a mile with the minimum of four five-ton trucks at just below 7 cents. The three and one-half ton trucks cost 1.22 to 5.92 cents respectively, the latter approached by the most costly of the two-ton trucks which ran from about 2 cents to 3.31, while the lighter vehicles with two exceptions were rated at 3 cents or less. The tires of the gasolene trucks show a maximum expense in the five-ton vehicles running from 8 cents to about 15; the seven-ton trucks, two of them, show a decidedly lower figure while the lighter vehicles average from 2 to 3 cents a mile.

Repairs on electrical vehicles are practically the same for all weights, the actual renewal figures on half-ton vehicles being in cents per mile, 4.82, 3.46, 2.68 and 3.78, against 3.30, 3.10 and 6.70 cents in five-ton trucks. The gasolene wagons show similar relations of the different classes, with a high spot in the five-ton trucks (15.40 cents) and in general, as might be expected from the multiplicity of parts, stand higher in cost than the electrics, figures of 10 and 11 cents being not unusual. Lubricants, a minor item in these costs, in the electrics mean one-fifth of a cent a mile and in the gasolene cars, nearly nine-tenths. The heavy gasolene trucks all surpass the half cent, half of them going above the cent and one up to 1.86 cents per mile. The last-named figure is the result of a four-year test with a total distance run of 22,300 miles.

The cost of garage has been figured for only sixteen out of a total of ninety-three reports considered and is very variable. For one electric of one ton capacity engaged in wholesale delivery, the figure is as low as $13 per year, while for two others in the same class they are $301 and $307, respectively. The minimum for gasolene was a seven-ton truck at $70 a year, with other figures, $271, $289 and $459.

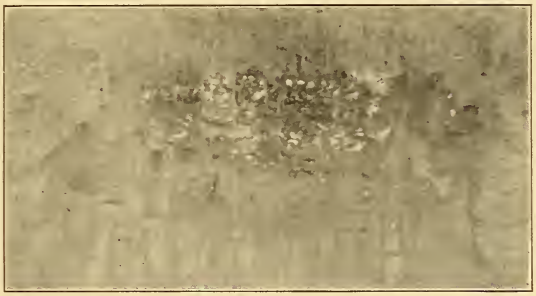
One of the interesting features of the latest report is the comparison of the manufacturers' estimates with the reality as developed for the first time by this investigation. In point of tire cost, sixteen electric trucks give a figure above the manufacturers' and eleven below; while in the gasolene vehicles twenty are above the guarantee and fourteen below. All the five-ton electrics were far above the commercial estimate and three of them more than double, while in the gasolenes of this capacity two were below and seven above with three of them more than double. In gasolene consumption the estimate is a reasonable average, the smallest cars—700 pounds—and the one-ton trucks showing the highest mileage per gallon—ten to twelve miles per gallon in the former and eight to ten in the latter—while the three-ton vehicles went from four to six miles. In the repair costs the electrics showed twenty-five of them above the manufacturers' estimate and six below, while the gasolenes were twenty-three above and nine below. In watt-hour consumption all the electric vehicles but two proved higher than the estimate and many of them twice to three times the estimate while in cost of battery renewals seventeen vehicles were high against nine below the commercial figure. Here the light vehicles depart most from the figure, a large proportion of them being twice the estimated cost, while the heavy trucks were pretty close to the manufacturers' estimates.

KITCHEN-MIDDENS AS ETHNOLOGICAL RECORDS

WHAT THE WASTE HEAPS OF EARLY MAN TELL US ABOUT HIS CUSTOMS AND HABITS AND HIS GRADUAL PROGRESS TOWARD CIVILIZATION

BY HERVEY W. SHIMER

As our present city waste dumps will give to the future paleontologist a pretty good conception of some phases of our material civilization, so the waste allowed to accumulate around the dwellings of early man give us a rude conception, at least, of his stage of development. Very early man, by a trait which inheritance has made comprehensible to us, threw the waste of food and clothing immediately outside his dwelling, there to accumulate. To such masses of débris the name kitchen-midden, literally kitchen refuse heap, has been applied. Since in many regions the food of early man was largely shell-fish, and these heaps of refuse would consist largely of shells, the name shell-mounds is also applied to them.



A small kitchen-midden: Gardiner's Island, New York. The numerous white shells outline the depression.. Upon the shells rests the horizontally and evenly bedded alluvium. The upper margin of the photograph is the top of the cliff.

Kitchen-middens vary much in size, from a length of a foot to that of a mile or more and from a thickness of a fraction of an inch to that of 100 feet; from the few shells, bones, and charcoal,—the refuse of a solitary hunter about his temporary camp, to the accumulations of a large village inhabiting the same locality through many centuries. Usually they have a diameter of 50–100 feet and a maximum thickness of two to five feet. In the permanent villages the dwelling came in time to occupy a depression in the accumulated mass. Besides being a repository for the waste of food, clothing and implements of war and hunting, they likewise were in many parts of the world used as burial places; just as many lowly tribes today bury their dead beneath their dwellings to keep them from disturbance and to have the protection of their spirits against enemies.

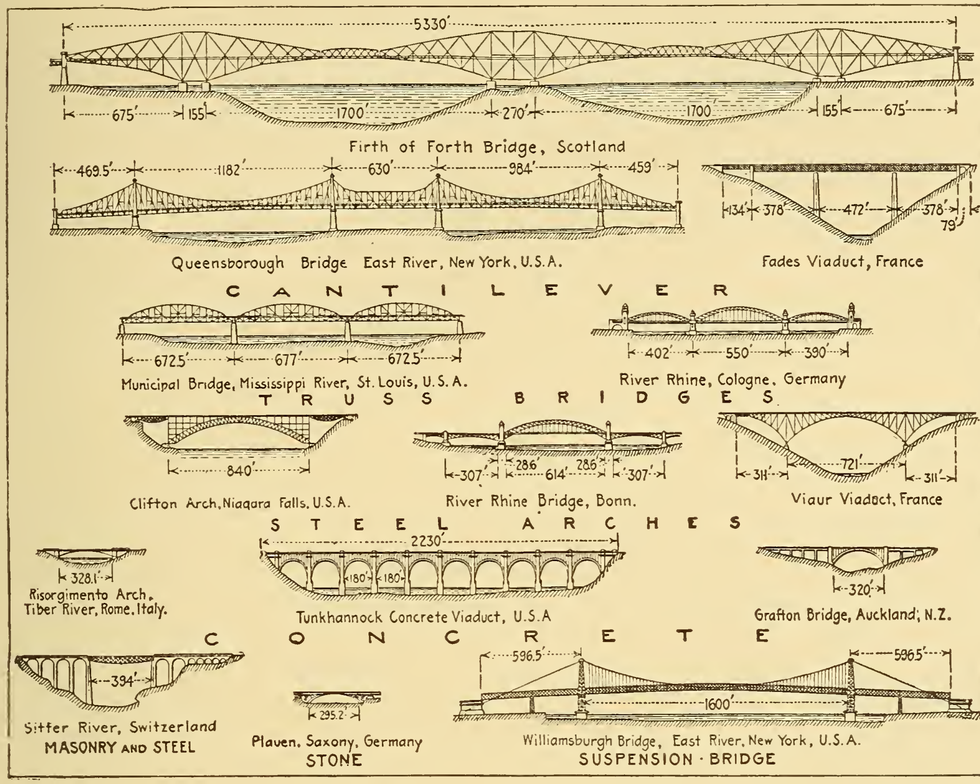
The distribution of kitchen-middens is world wide, they are found on all continents,—North and South America, Europe, Asia, Africa and Australia. They usually occur on the margins of bays or inland along streams and lakes. They frequently, in this country, occupy the same sites as the later white settlements and for the same reason,—accessibility to water, food, and wood. The character of the middens naturally varies with the character of the food. Along the ocean margins the waste was marine shells and the bones of fish and mammals; inland it was fresh water shells and the remains of land animals, though the presence here of some marine forms indicates a system of traffic such as was practised by the Indians upon the arrival of the whites.

The shell-mounds of the coasts of Maine and northeastern Massachusetts contain principally the remains of the clam, oyster, quahog, hen clam, scallop, deer, beaver, wild turkey, great auk, and many kinds of fish; with these occur fireplaces, charcoal, flint implements, and a little pottery. Many are the remains of animals now absent or very rare in these regions; among these are the oyster, quahog, wild turkey, and great auk. The presence in a midden at Ipswich Mass., of human bones broken into short pieces as for the cooking pot gives indication of cannibalism. This practice has been shown to have occurred at other places, as Florida, along the Atlantic Coast.

Kitchen-middens vary in abundance with the suitability of a region for habitation. In the San Francisco Bay region 425 good sized mounds have been counted. They are also very numerous along the Atlantic Coast from Newfoundland to the West Indies and around the Gulf. This abundance was called to the writer's mind when making some geological observations on Gardiner's Island with Prof. W. O. Crosby. This small island lies south of Connecticut, at the east end of Long Island. On the east side, within a length of 100 feet of sea cliffs, the ocean waves had sectioned three small middens. The photograph shows one where the fire had been built in a depression in the brown loam; the fire has turned to a red color the four to six inches of soil bordering the pit. At the place of sectioning the depression is two feet wide by a foot deep and covered with almost a foot of alluvium washed from the slightly higher slopes to the north; within it were collected charcoal, burned pebbles, the very abundant scallop (Pecten irradians), quahog (Venus mercenaria) clam (Mya arenaria), oyster (Ostrea virginiana), also a few specimens of the decker (Crepidula fornicata), jingle shell (Anomia), blood clam (Scapharca pexata) and a fulgur, besides the bones of some fish and birds and broken pottery. Other middens thus sectioned were noted along this coast. For the retreating sea cliffs to expose so many at any one time the total number on the island must be very large.

Kitchen-middens are also very abundant in France, Denmark, Scotland, Italy, and Japan. In northern Italy they have received the name of terramara (bitter earth). They contain few or no shells but are phosphate deposits. These represent the accumulations beneath dwellings built on piles; and their slow accretion took place during the time when this region, especially that lying between the River Po and the Apennines, was gradually changing from a condition of shallow lakes, or marshes with frequent inundations, to that of dry ground. These dwellings began apparently at the end of the Stone Age there and reached their greatest development about the fifteenth century B. C. The terramara deposits are apparently intermediate between the kitchen-middens proper (shell-mounds) of northern Europe and elsewhere and the lake dwellings of Switzerland; the different kind of accumulated waste indicating both the kind of dwelling used and food eaten.

The remains of shell-mounds (kitchen-middens proper) indicate that they were accumulated by peoples but slightly if at all acquainted with agriculture, whose subsistence depended mostly upon fishing and hunting, and who were largely in the Neolithic period of culture. Some mounds in the San Francisco Bay region must have been occupied for four or five thousand years at the least. This estimate is based largely upon the probable number of shell-fish, birds and mammals eaten by one individual and the approximate number of individuals in the village, reckoning each depressed area as the dwelling place of one family. Some of the mounds were occupied after the advent of the whites. The same is true on the Atlantic Coast. In the Ipswich mound referred to above, it was only near the top of the mound that any objects of European make were found. Similarly on this coast the presence of rare or extinct species gives evidence of the lapse of many centuries since early man began here his primitive housekeeping. In the Americas the Indian is, at least in many cases, known to be the direct descendant of the kitchen-midden inhabitants.



Through the courtesy of the *Engineering News* we are able to present to our readers a diagram of some of the world's largest bridges. These are all drawn to the same scale and show the principal examples of the cantilever type, of truss, steel arch, concrete, masonry, and suspension bridges. The largest of these types is shown in each case. The Firth of Forth Bridge has the largest cantilever; the Municipal Bridge, the largest single plain truss; the Clifton Bridge, the largest steel arch; the Risorgimento Arch, the longest concrete arch; the Plauen Bridge, the longest stone masonry arch; and the Williamsburgh Bridge, the largest suspension bridge.—L. E. M.

TRANSPARENCE OF METALS

It has been known for come time that certain metals when heated become more or less transparent. It has now been shown that a sheet of glass covered with an extremely thin layer of silver also becomes completely transparent when heated in the presence of oxygen. Its transparency becomes visible at 240 degrees and becomes perfect at 390 degrees. It is supposed that there is a temporary combination of oxygen and silver which is afterwards broken up as there is no change in weight before and after the experiment. Thin leaves of copper heated under the same circumstances become transparent and emit an emerald green light. L. E. M.

A SEVERE TEST

On June 20 last, at Coatesville, Pa., two steam boilers of different types, one called the sectional and the other the radial stay, were filled with water which was then converted into steam by oil fires. The water was entirely boiled away in the sectional boiler which stood the test until the end, but the radial stay boiler exploded before the water was entirely boiled away.

L. E. M.

Science Conspectus is published December, January, February, March and April.

WASHING MONEY

The United States Government has recently begun to wash and iron its soiled paper money by machinery. It is expected that this machine will save the government a large amount of money and also prove an economy to bankers in all parts of the country. The money passes through the machine between two duck belts which run over copper rollers. These rollers are so shaped as to impart a scrubbing motion to the soiled currency. The whole washing operation is carried out in a 100-gallon tank filled with a solution in which a special soap is dissolved. When the washing is completed, the bill is run through a tank of clear cold water and then a jet of air whisks it to another duck belt which carries it over gas-heated drums which dry the paper. It takes less than two and a half minutes for the bank note to pass through the machine. A supplementary machine irons the bills by passing them over heated drums and subjecting each one to pressure of compressed paper rolls. L. E. M.

AN AUTOMATIC WAITER

One of the principal items of cost in running a restaurant is that of waiter service. It is reported that an Australian has started the thin point of the wedge into the cost of living in inventing an electric waiter which is operated by the customer seated at his table.

A wooden frame holding the menu card is fitted with push buttons opposite each item, and "pressing the button" rings a bell in the kitchen and displays the order and the table number. The kitchen apparatus also prints a check the original of which comes to the customer, with a duplicate on an endless tape. This device has been in successful use in New Zealand.

IS THE ATLANTIC COAST SINKING

From time to time the assertion is made that there is a general movement of the earth's crust along the edge of the ocean. The Atlantic Coast of the United States has recently been studied by Johason, a French geographer, who has drawn the conclusion from his studies that the disturbances reported have been purely local and that there is not a general coastal settlement.

Of course the studies of any one man are extended over a comparatively short period of time and do not serve to tell us whether or not the great coastal movements, which we know have taken place in geologic times, are at present occurring. L. E. M.

VENTILATION FROM A NEW STANDPOINT

British physiologists have devoted a large share of their energy in recent years to the problems connected with respiration. Leonard Hill is perhaps the most prominent of a group whose names are associated with fruitful studies in this field. It is, therefore, interesting to consider a summary of his views concerning ventilation. Such a statement in a condensed and popular form he has embodied in a presidential address before an English association and it has been reprinted by *The Popular Science Monthly*.

The article reads like a stenographer's report and various slips of the tongue—or instances of careless proofreading—appear in it. These can be overlooked; though a New Englander resents the obvious confusing of the intellectual Laura Bridgman with the hapless defective known in physiological literature as "Strümpell's patient." The really important matter of the address can be divided into two parts—first, a review of the doctrines previously held and of the transition to current beliefs and, second, the considerations which are more distinctly the speaker's own.

The readers of this magazine are so familiar with prevailing views that only the briefest statement need be made. It has been established that lack of oxygen is practically unknown under the worst conditions of crowding, and restricted air-supply, so long as we are observing subjects at the sea-level or at ordinary altitudes above it. Hill points out effectively that in the most intolerable situations in shops, mines, or tenements the oxygen supply is more liberal than in the celebrated health resorts of the Alps. Increase of carbon dioxide to the percentage which clearly disturbs the human system is only the remotest possibility. In the light of these facts men of science turned for a time to the hypothesis of "crowd-poison" to account for the untoward effects of deficient ventilation. It was maintained that organic exhalations from the respiratory tract, the mouth, the skin, and the clothing must accumulate in the stagnant air.

Crowd-poison still has its protagonists but can be said, on the whole, to be in disrepute. Hill makes light of it. He recognizes, of course, that an odor in a stuffy room must have a chemical basis but he points out that such odors cease to be apparent to persons who continue to breathe the vitiated atmosphere. The assumption is made that the sensation completely measures the influence of the odorous material on the organism. This appears to the reviewer to be utterly unsafe. Crile has abundantly proved that central anæsthesia does not insure the neutralization of the effects of stimulation through afferent paths.

Hill fully endorses the teaching to which we have become accustomed that there are but two qualities in the air of ill ventilated places that are at all likely to make themselves felt, high temperature and high humidity. In fact, it might be claimed that only one of these, high temperature, need be considered. For high humidity is not significant in connection with moderate temperatures. Lack of movement in the air might be mentioned as another detrimental condition but this is really tributary to the two just mentioned. If there are no currents, the air next the skin of the face and hands is not briskly exchanged for fresh portions and it becomes warm and moist. Hence the surface of the skin would be as warm in a room filled with still air of a certain temperature as it would in another room where the mercury was standing several degrees higher but with the air in circulation. Hill is an advocate of the electric fan.

But we must pass to the more novel parts of the address. The speaker tells us that when the ideal of the architect and the engineer is attained—the older standards being sought—the result is far from satisfactory. The air of the work-room or the school is chemically correct, its temperature is 68° F., there are no draughts,—but the occupants are

sluggish and depressed. Very likely they complain of the ventilating system. The cause of their dissatisfaction *is*, in a word, that the environment is *unstimulating*. We have been so anxious to eliminate disturbing factors that we have produced an unwholesome calm. The human body is not accustomed, to the suspension of external stimulation; it has been developed under such spurring and tends to lose tone and efficiency when shielded from it.

If we analyze the effect of the absence of stimulation we shall probably be safe in concluding that one result is a vascular relaxation, presumably with some decline of the arterial pressure. Another is a softening of the musculature. Both these changes are such as favor mental passivity and scattering. They are characteristic of the approach to sleep. When we go to bed we aim more or less successfully to exclude stimuli of all sorts and we welcome the ensuing lapse through reverie to unconsciousness. But when it is our purpose to concentrate the attention we avoid absolute comfort. We do not resort to a hammock or a morris-chair. Hill affirms that when we have neutralized draughts and secured a mild, uniform temperature we have shut out possible promoters of nervous activity. He would therefore prefer that ventilating and heating systems should not work too well. A touch of chilliness and a perceptible air current he would regard as desirable. Certainly it is worth while to consider that the most comfortable climates do not produce the dominant races and we have perhaps pampered ourselves unwisely by approximating such climates in our homes.

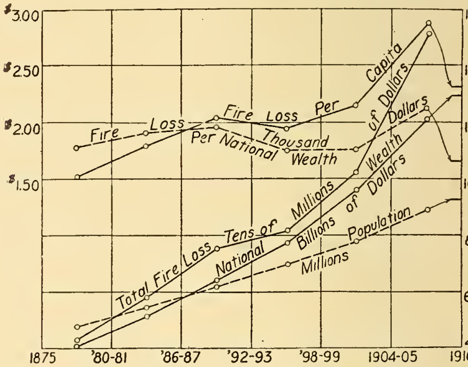
There is a corollary to Hill's contention which might not be foreseen. It is that low diet makes people seek the lifeless air of ill-ventilated houses. They cannot meet the demands of more bracing conditions because they have no fuel to spare. The case of the Newfoundland fishermen is cited: they are so underfed that they huddle in warm cabins and the hardening effect of their laborious occupation is more than counteracted by the relaxation under shelter. They are dying at an appalling rate from tuberculosis. Here, then, we have a fresh protest against the doctrines of Chittenden. Hill maintains that colder rooms with air in motion will make us more hardy and alert, but that liberal feeding must be maintained to meet the tax upon the heat-producing tissues.

PERCY G. STILES.

FIRE LOSSES IN AMERICA

The historical progress of fire losses in the United States for the last thirty-six years is shown by the accompanying diagram, produced from the *The Engineering Record*.

In order to smooth over inequalities due to extreme losses one year and considerably lower ones the next, the chart has been figured out on the basis of averages for six years, and is so plotted. There are five curves presented, of which the one depicting the total fire loss, in tens of millions of dollars, shows the greatest rate of increase at practically every point across the chart. It is growing faster than the national wealth, and very much faster than the population.



During the 36 years covered by the chart the fire loss in the United States has amounted to the stupendous figure of $5,120,622,540. This is more than 7 per cent on the average value of national wealth over this period of time. As a matter of fact, the present annual gain in wealth, which is about $4,600,000,000, represents only the capital at 5 per cent, of our annual fire loss which amounts to $230,000,000 per year.

SCIENCE CONSPECTUS

VOL. III JANUARY, 1913 No. 2

AN HONEST LABEL

SOME OF THE METHODS EMPLOYED TO "COMPLY" WITH THE LABELLING PROVISIONS OF THE PURE FOOD LAW AND AT THE SAME TIME MISLEAD THE PUBLIC

BY A. G. WOODMAN

THERE is a clause in the Federal Pure Food Law under which an article shall be deemed to be *misbranded* "if the package containing it or its label shall bear any statement, design, or device regarding the ingredients or the substances contained therein, which statement, design, or device shall be false or misleading in any particular."

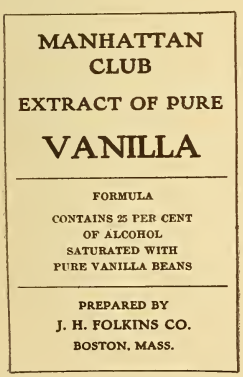


Figure 1. A Weak Extract Although "Saturated"

Not all of the work of the chemists engaged in the control of food adulteration, fortunately, is concerned with the detection of actually poisonous or even deleterious substances. As a matter of fact, the greater share of their energy is directed to learning whether or not the label on a food package correctly represents the character of its contents. Much of the present propaganda in the interest of pure food, especially from the standpoint of the consumer, can be summed up in the three words that are at the head of this page —"An Honest Label." In many cases accurate and true statements of the contents of the can or package constitute the only protection needed by the purchaser, and are fully as efficient and much cheaper than prosecutions or restrictive measures. The reasons for using antiseptics and artificial colors, and otherwise adulterating foods, may be questioned, but no one will deny the right of the consumer to know it whenever adulteration has been practised.

Plain labelling constantly involves the meaning of words. The courts have universally held in construing all law that words shall be given their ordinary meaning in matters of interest to the public, and the meaning of words used in their ordinary sense is a question for the courts. In practice, however, it seems to be the idea of certain manufacturers of foods that a label is placed on a package for the purpose of conveying *mis*information as to its contents.

Even common household terms, formerly employed to convey the meaning of superior quality, are used as a mantle to conceal false pretense. "Absolutely Pure," "Warranted a Superior Article," are only trade names which to the initi-

ated have no more significance than the term "Strictly Fresh" as applied to eggs. The term "Home Made" covers some of the most highly developed products of synthetic organic chemistry. "Mrs.

Figure 2. "Dutch" Products from Michigan

Williams' Home-Made Ketchup" more likely than not consists of grated turnip, filled with starch, colored with eosin, preserved with benzoate of soda and flavored with methyl valerianate and other products of the chemists' art.

Elements of a Label

The ideal label should tell *where a product was made, by whom it was made, and its true nature and substance.* All of this, and any additional information which the law requires in order to make known any adulteration by addition or deficiency should be in such *position, type,* and *terms* as will at once be *seen, read* and *understood* by *the average purchaser or consumer.*

Plain labelling of this kind, fair in theory, is difficult to put into practice. Investments are so enmeshed in the web of fancy which advertising agents and label designers, without regard to the facts and wishing only to emphasize every food term indicative of purity and quality, have woven throughout the food industry, that the changing and adjustment of labels means financial loss and widespread disturbance. The manufacturers object especially to any statement regarding the age of the product or the location of the factory and they have in general not been obliged to furnish this information on the package. It cannot be gainsaid, however, that these statements may be to the consumer indices of superior or inferior quality and the omission of them in the labeling is a special privilege to the food industry and a prejudice to the consumers' rights.

One thing, nevertheless, is to be insisted upon and that is that the label *shall tell the truth.* This has been the requirement for years in trade-mark law and the same principle holds true as regards labels that are to be respected by the food laws. Trade-mark protection has been denied by the courts, for instance, to a product labelled "Balsam of Wild Cherry," when the balsam was not made from wild cherry; to the "Balsam of a Thousand Flowers," when the compound was not derived from flowers;

Figure 3. Cotton-seed Oil Masquerading as Olive

to "Laird's Bloom of Youth," labelled to be "free from all mineral or poisonous substances," when the so-called article

contained carbonate of lead and other noxious ingredients. In this spirit was framed the clause in the Pure Food Law quoted in the opening paragraph, and it will be of interest to consider some specific examples which show the need for such enactment in the case of food labels, that they may fulfill their purpose of *keeping the consumer fully informed.*

Misleading Labels

Labels may convey information which is perfectly true *per se*, or which is a matter of honest opinion, but which is

Figure 4. Italian Macaroni made in America

so arranged or stated as to convey a wrong impression. A label reading

SUPERIOR
IN
QUALITY, PURITY AND FLAVOR
TO ANY
OLIVE OIL
ON THE MARKET

especially when the lower part of the label bears a representation of a dove carrying an olive branch, could hardly help giving to the mind of a purchaser who sees it upon the grocer's shelf the impression that it is olive oil. Yet it will be observed that the label does not actually state that the bottle contains olive oil, and as a matter of fact the sample was a mixture of cotton-seed and corn oils. Whether or not this mixture is superior to olive oil is a question open to argument.

In the same way, when one reads upon a bottle of spring water the statement "This Spring Water was placed FIRST in the Report of the State Board of Health,"

OLEO-MARGARINE.

BUTTERINE.

Figure 5. Compare this with Fig. 7 for "Plain Legible Type"

it is surely pardonable for him to assume that the spring water occupies this high eminence by virtue of its quality and exceptional purity. Yet the only reason for placing this water first is that the list of spring waters examined by the board is arranged alphabetically and the name of this particular one begins with the letter "A"!

Still another instance will illustrate the ingenuity displayed in imitating labels on packages of established reputation in order to convey a similar impression in behalf of an article of questionable value. Manufacturers of cream of tartar baking powders often put on the label a statement authorizing grocers to guarantee that the powder is free from alum or other adulterants. The can of the "Boston" baking powder used to bear a label reading after this manner: "All grocers are authorized to guarantee bread, cake, pastry and all products in

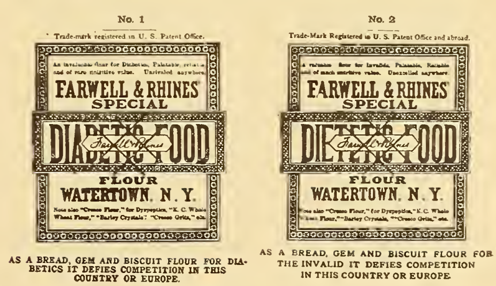


Figure 6. An "Improved" Label

which our powder is used free from alum, lime, ammonia, terra alba, Rochelle salts or anything injurious as a result of

its use." At first sight this guarantee would appear to be of the kind used on genuine cream of tartar powders and

Figure 7. The Manufacturer's Idea of "Plain Legible Type"

even stronger in its protestation. The little "joker" lies in the fact, however, that they do not guarantee that the *powder* is free from these harmful things but that the *bread*, *cake*, etc., is free. As a matter of fact the powder contained alum, terra alba, and ammonia, but since these are partially changed during the baking they are not present in the same form in the final product. Hence the statement is theoretically true although ingeniously deceptive.

In the Manhattan Club Extract of Vanilla (fig. 1), the same policy of deception is carried out by the use of the word "Saturated," conveying the meaning of great strength. In reality the extract is a very weak one since 25 per cent. alcohol will dissolve but little from the vanilla bean. Makers of high-grade extracts use much stronger alcohol, even of 60 per cent. strength, in making vanilla extract. Plain water might have been used in making the extract just about as well. To be sure, it would take practically nothing out of the vanilla bean, but then it would be "saturated" (for water).

The misbranding clause of the law takes a step further, and a very natural one, too, when it recognizes the fact that a label may be misleading pictorially or from its design, without the use of words at all. The picture of an Arab on horseback and of a lady in the costume of the island of Java on a can of coffee conveys the idea as to its origin just as plainly as if the words "Mocha and Java" were there.

The picture of a Dutch windmill on the package of Holland Rusk (fig. 2) would probably be sufficient, taken in connection with the name itself, to impress the purchaser with its foreign origin even if he were not told definitely in large letters that the product is "Made in Holland." Since the passage of the Pure Food Act, however, he is vouchsafed the interesting information that it is Holland, *Michigan*, where these Dutch windmills dot the landscape.

Figure 3 is from a can of "Extra Fine Olive Oil" and, while not an especially good example of the photographic art, shows an Italian girl picking olives from the tree and in the upper corner a portrait of the King of Italy. From the standpoint of plain truth this label would be

Figure 8. "Compound" Packages evasively marked

greatly improved if it showed negroes picking cotton in a southern cotton-field, and a representation of the President of the United States, for the contents

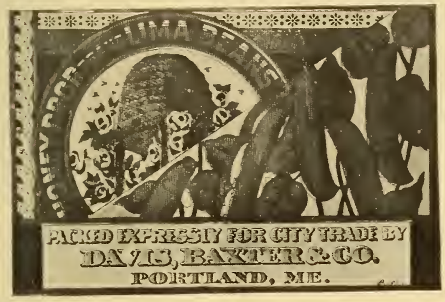


Figure 9. Note the word "Soaked" just under the Beehive

of the can consisted almost entirely of American cotton-seed oil.

Another form of this pictorial misrepresentation is seen in figure 4. It is a common occurrence to find articles of domestic manufacture labeled in imitation of foreign products. Especially is this so when the imported goods, by reason of inherent quality or popular demand, have achieved a considerable reputation. In the macaroni label the view of the Bay of Naples, with the volcano in the background, the people in Italian peasant costume eating macaroni in Neapolitan style, even the characteristic sailing craft and the insignia of the Italian merchant marine in the upper corner conspire to confirm the belief of the unwary purchaser that this is truly an imported brand of macaroni. The only discordant note in the label is the line "Manufactured in New York State" which was printed on the label at the earnest request of the government food officials. Although out of harmony with the rest of the picture, it imparts valuable information to the consumer.

It is not always possible to convey this warning information to the consumer in so direct and positive a manner as in the case just mentioned. It sometimes happens that the deceptive part of the label consists in a word or phrase which legally is all that must be changed. This change can be made by the producer in a liberal spirit or it can be made so as to just comply with the law. There are producers and producers, and while some meet the officials more than half way, others will not step more than an inch over the line. Figure 5 shows a diabetic flour, the sale of which was highly objectionable in that it contained a very large proportion of starch. The illustration on the left is the original label and the one on the right shows the manufacturer's method of compliance with the law. By eliminating all reference to its diabetic use, the product is no longer illegal, but the change from the word "Diabetic" to "Dietetic," as shown in the figure, is not very strong evidence that the manufacturer of this product has the welfare of the consumer much at heart.

Even the very words or marks that the Government requires to be placed on

Figure 10. Proper Use of Word "Style"

certain foods to notify the purchaser of their inferior quality may be so construed or distorted as to appear to have a distinctly different meaning. For example, it is

Figure 11. Compare Prominence of "English" and "Style"

required that renovated butter shall be marked on every print or package with the words "PROCESS BUTTER" or "RENOVATED" in order that it shall not be sold as genuine butter, it being as a matter of fact a product which has been worked over and purified; in other words it must be marked with a qualifying term or word so that it may be known to the purchaser that it has gone through this treatment. Does this requirement phase the producer? Not a bit, as witness the following advertisement clipped from the daily paper: "The U. S. Government says that every tub of *B. & M.* brand of renovated butter is PURE, and that

Figure 12. Evasive Use of Word "Style"

Uncle Sam guarantees it so, and that every package shall be branded 'RENOVATED' to show its quality."

Illegible Type

Another large class of labels which do not measure up to the standard set in our discussion of an ideal label comprises those in which the information required by the regulations is put on to be sure, but in such small type or so obscurely as to defeat the purpose of the requirement. The ideas of the manufacturer as to what constitutes "plain, legible type" are often at variance with those of food officials.

In the original requirement regarding the labeling of oleomargarine to distinguish it from butter, the only specification was that the word "oleomargarine" or "butterine" should be printed on the package in "plain Roman type" of a certain definite height. The style of type that was in the minds of the State Board of Health is shown in figure 6, the manufacturer's conception in figure 7, which shows facsimiles of stamps in actual use. The word oleomargarine is printed in skeleton letters, although of the required height. The hieroglyphic at the top is the phrase "Adulterated Butter."

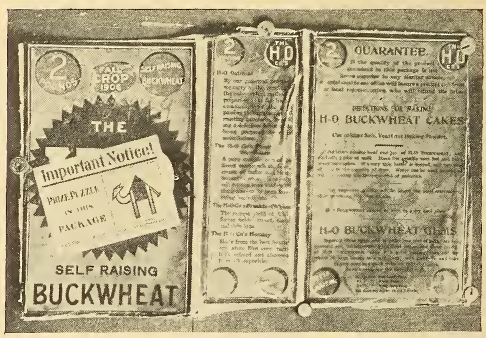


Figure 13. A "Compound" Package Not Plainly Marked

Especially good illustrations of this class of labels are to be found among the so-called "Compound" goods. It has been in the past, and still is in certain places, permissible to sell articles containing cheaper substitutes provided they were not injurious to health and if they were plainly marked with the word "MIXTURE" or "COMPOUND." Some of the most interesting cases of dishonest and evasive labels have been perpetrated under cover of this provision of the law. The word "Mixture" is not so common, it apparently not lending itself so readily to purposes of deception, but the word "Compound" can be so used as to represent to the purchaser the idea of an improved process of which he is getting the benefit. This is especially true when the word is used in a sentence or phrase, as "Warranted the Best Compound," or "Specially Compounded for Family Use." The word has been often woven into the design of the label or tucked away in some obscure corner so as to escape detection. The spice packages shown in figure 8 all bear the word

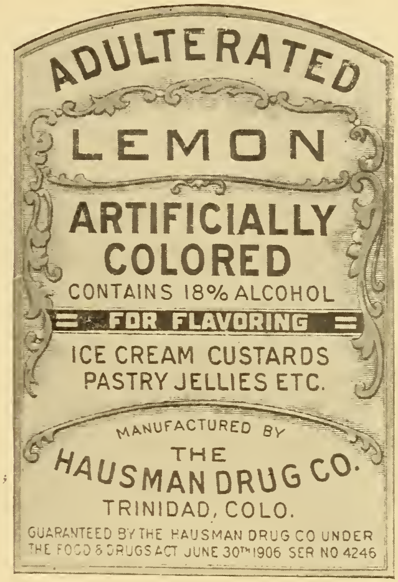


Figure 14. An Honest Label

Figure 15. Plain Labelling

"Compound" in "plain, legible type," although much less diligent search will be needed to show the words "Pure," "Fine" or "First Quality" on some of the same packages. On one of these packages the word is apparently missing, but if the cut were large enough it would be found that on the side of the can is printed a pleasant tale relating how of all the mustards examined at the World's Fair the award was made to this one as "the finest mustard compound."

A parallel case is that of the requirement that old and mature vegetables which have been soaked in water and then canned shall be marked with the word "SOAKED" printed conspicuously on the labels. It is sometimes put on in some such way as the following, copied from a can of soaked peas: "These goods are prepared from selected stock and soaked in the purest artesian well water," thus giving the impression that the soaking is an essential part of some superior method of preparation. Figure 9 shows an instance where the word "SOAKED" is not given striking prominence. Possibly the statement on the label "Packed expressly for city trade" conveys a gentle thrust at the degree of familiarity of urban residents with the genuine products of the farm.

Under the regulations for the enforcement of the Federal Food and Drugs Act it is forbidden to use a geographical name in connection with a food product not manufactured in that particular place,

Figure 16. Example of "False Statements"

or to use a distinctive foreign name upon an article of domestic origin except as an indication of the type or style. That is, the characteristic foreign name must be modified by the word "type" or "style" if the food is not from the exact geographical locality implied. Figure 10 shows such a case in which the word "Style" is exhibited in large type and as prominently as the principal word on the label. This is not true to the same extent, however, in the label shown in figure 11, and this decreasing scale of prominence reaches perhaps its low-water mark in figure 12, where by close scrutiny the word "Style" can be found coyly hiding between "Japan" and "Rice."

In the package of self-raising buckwheat flour shown in figure 13, it is interesting to note the prominence given to the word "Buckwheat," it appearing in large letters in various places on the label as well as in several of the medallions. This preparation contains in addition to the buckwheat a considerable proportion of the cheaper wheat and corn flours, such a mixture being in fact preferred by many to the straight buckwheat. Such being the case, there would seem to be no valid reason for not stating the fact that it consists of such a mixture openly, and giving it as much prominence as is given to the word "Buckwheat", instead of assigning it the obscure position that it occupies at the lower right hand corner of the label.

After these instances of labels obscurely marked by manufacturers who evidently do not desire that the purchaser shall know the exact character of the product, it is rather refreshing to see the two examples shown in figures 14 and 15, where the producer obviously does not fear to call a spade a spade, and very likely does not find his sale of these articles diminished by reason of his frankness. A label of this kind, it must be confessed, is, however, somewhat of a rare bird.

False Statements

The third and last form of dishonest label that it is necessary to take up is

Figure 17. Label Entirely Incorrect

that in which incorrect or false statements are included. These may depart very widely from the ideal label or from the ordinary ideals of common honesty, and

in many cases would pass unchallenged were it not for the watchfulness of the food officials. The most positive and direct statements on the label may be absolutely controverted by the analysis of the product. Hundreds of instances might be drawn from the packages of patent medicines to illustrate the point, but one will suffice, chosen because the analysis is one of many made in the Institute laboratories. The label on a package of Dr. Fahrney's Teething Syrup contained the following statements among others: "A sure remedy for all ailments incident to babes from one day old to two or three years. . . . Contains nothing injurious to the youngest babe . . . Mothers need not fear giving this medicine to the youngest babe, as no bad results come from the continued use of it." Yet this preparation was found upon analysis to contain alcohol, chloroform and morphine!

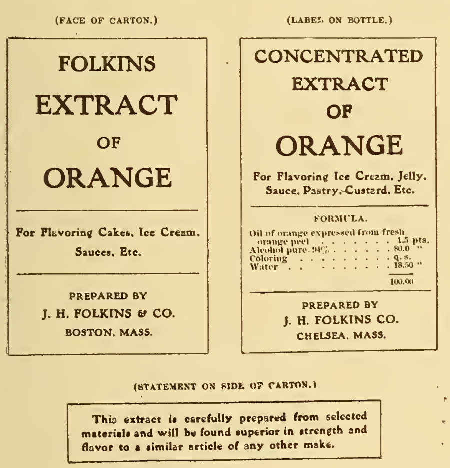


Figure 18. A Contradictory Label

But it is not necessary to go to the patent medicines to get examples. Similar instances can be found in food products, although as a rule they are not so flagrant. The can of "Digesto" coffee shown at the left in figure 16 bears the statement that it "Contains no caffein or tannin," and yet a chemical analysis of the product showed that it contained about 12.50 per cent. of caffetannic acid, which is the tannin of coffee, and 1.05 per cent. of caffein; that is, of both of these it contained practically the same amount that is present in ordinary coffee. A large shipment of this coffee was seized by the government authorities en route to Boston from New York and was released by the courts only upon the filing of a bond that the objectionable portion of the label would be eliminated. Hence the revised label shown upon the right in the figure.

Some years ago, before the food officials were so fussy, a well-advertised breakfast food bore a statement on the package that was decidedly reprehensible, in that in addition to being untrue it was liable to prove a distinct injury to a class of invalids who might be misled by it. In the reading matter on the side of the carton was the statement: "This food, being almost entirely of pure gluten, is highly recommended for diabetics or those of weak digestion." The product contained not over 14 per cent. of gluten but did contain approximately 75 per cent. of starch, the very thing that diabetics are trying to avoid. A diabetic patient who used this product, relying upon statements like the above, would in reality be choosing a quick method of committing suicide.

The sample shown in figure 17 is of interest because so many misstatements are condensed into one label. In the first place, the name of the firm is a fictitious one, the product being as a matter of fact made and marketed by an entirely different company. Further, the material, although labeled to imply that it is of French origin, is entirely a domestic product. Finally, the substance is not coffee at all but a mixture of chicory and roasted cereals!

It is not unusual to see on a label itself a flat contradiction, as witness the orange extract shown in figure 18, which furnishes to the thoughtful purchaser a bewildering variety of information. The label on the carton, which is the only part of the package that the customer sees until he has purchased it, not only affords no intimation that the article

is not a standard extract but actually asserts it to be "superior in strength and flavor." The label attached to the bottle represents it as a "Concentrated" extract, and the formula, which is the truthful part of the label, shows it to be only one third of standard strength.

One more illustration of this class of labels must suffice. Figure 19 shows in the upper portion a photograph of a label in use prior to the passage of the Pure Food Law, and below, the same label as it appeared afterward. The change is evident and the natural inference that would be drawn as to the amount of

Figure 19. One Effect of the "Pure Food Law"

Java and Mocha coffee that was present at any time is the correct one.

These illustrations might be greatly multiplied but enough have been given to show that there is work to be done by some one if food labels are to tell the truth, the whole truth and nothing but the truth. The question is not one of actual danger to the public, of possible injury to the consumer, but it is perhaps of only a degree less importance that the purchaser should be protected in his inherent right to know what he is buying and paying for. In this kind of work the food officials are upheld by all honest producers and merchants, who are always willing to describe truthfully the character of the goods in which they deal. Nor would it be expected to be otherwise.

The food industry itself should and does welcome as much or more than the consumer the enforcement of pure-food legislation. The very foundation and success of business have demanded strictest integrity in transactions among individuals and firms. The brands which have the widest sale have been established by years of square dealing with consumers. And when the food laws require all firms to deal honestly with the consumer, not only as a matter of principle, but as a matter of law, both as regards the label on the outside of the package and the product within, the results will bring a far-reaching benefit not only to the consumer but to every producer, manufacturer and dealer.

CARRYING COAL BY PIPE LINES

A MACHINE has been invented which is designed to mine coal in the granular or powdered state, mix it with water and then pump it through a pipe line to its destination. It will then be separated from the water and dried, and it can be used for almost all the purposes for which the lump coal is now employed.

According to the engineers who have designed this machine, it has proved by tests so economical in operation that they say it may change the whole art, not only of mining, but of transporting and consuming coal. The machine is automatic, it being advanced by a hydraulic feed mechanism.

The rotary cutters, which are not unlike a circular saw, are driven by an induction motor. The coal is pulverized by these cutters and washed into a nearby receptacle by a powerful stream of water. From this receptacle it is pumped to any desired point. L. E. M.

BACTERIA AND PROTOZOA*

WHAT THEY ARE, AND WHERE THEY BELONG IN WORLD OF LIFE — SOME DISTINCTIONS THAT CAN BE DRAWN BETWEEN THE TWO GROUPS OF MICROSCOPIC LIFE

BY F. SCHNEIDER, JR.

THE most striking distinction that can be drawn between protozoa and bacteria is embodied in the statement that whereas the former are animal microbes, the latter fall among the plants. The members of both groups are true microbes,—"little living things," so small indeed as to be discernible only with the aid of a microscope. In both cases the microbes are unicellular, consisting of but a single cell or unit of living matter; thus representing the simplest form of organization known in the living world. Similarly, the organisms of both groups are naturally aquatic in habit, requiring moisture to best carry on their activities, and in both instances examples are found of the capacity for spontaneous movement. But while the two groups have these and other characteristics in common, it is generally agreed that the protozoa occupy the lowest and most elementary position in the animal kingdom while the bacteria hold a similar position among the plants.

This clear-cut distinction is supported by various supplementary differences. For one thing, the bacteria form a simpler and more compact group. They are neither so large nor so complicated in structure as the protozoa; nor do the members of the group exhibit as wide a divergence one from another in form. A good example of bacterial structure is the common hay bacillus. This organism, an inhabitant of the soil also commonly found in air and water, is a minute rod about one five thousandth of an inch in length and one twenty-five thousandth of an inch in diameter. Structurally it is a mere bit of living matter (or protoplasm) held in shape by a thin skin or membrane. The tiny cell is so minute that even with the most powerful microscope its internal structure remains a subject of conjecture. Under suitable conditions it can, however, be made out that the cell is covered with minute thread-like processes, which from their whip-like appearance have been termed flagella. It is by means of the flagella that the organism propels itself through the surrounding fluid. Under unfavorable conditions, such as of food supply or moisture, the hay bacillus can concentrate its protoplasm into a very dense ball, or spore. These spores are extremely resistant to heat and drying, but when normal environmental conditions are restored will germinate into the ordinary form. The reproductive process is of extreme simplicity; a constriction appears in the centre of the full-grown rod, deepens, and finally separates the two parts, which grow again to full size. The appearance of this organism is made clear in figure 1.

The same simplicity of structure is displayed by the other bacteria, although many cannot form spores, and many do not possess flagella and the accompanying power of free movement. Aside from the group of rod-shaped or bacillus forms, practically all the bacteria fall into two other classes, — spherical ones, or cocci (pronounced cock's eye), and spirally twisted ones, or spirilla. These forms are illustrated in figure 2. The structure is essentially the same, a simple bit of protoplasm surrounded by a delicate membrane.

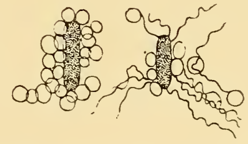


Figure 1. *The Hay Bacillus.* Some of the flagella have curled up in the drying process, preparatory to staining.

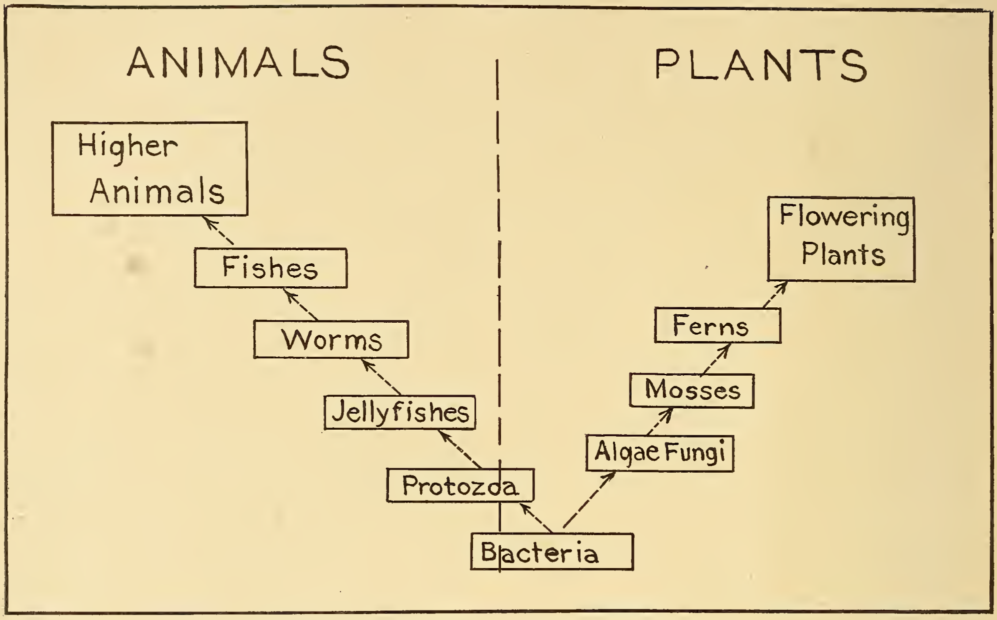


Figure 7. Relationship of Bacteria and Protozoa

When we now come to consider the protozoa we find that these animal forms are decidedly more complex. They are, still, like the bacteria, each a single cell, but the parts of the cell have become differentiated to special purposes. Even the simplest forms like the Amoeba, shown in figure 3, exhibit this differentiation. A constant component of the protozoan cell is the nucleus, a specialized part of the protoplasm, not present in the bacteria but always found in cells of the higher forms of life. The nucleus seems to have regulative powers over the cell, and to be particularly involved in the process of reproduction. Referring again to Amoeba we see that it contains certain clear spaces, or vacuoles. Some of these function in the absorption and digestion of food, while others serve in disposing of waste products. No external membrane is present in Amoeba; in motion the organism simply pours out its naked protoplasm in the line of movement and so rolls, as it were, over and over on itself. Reproduction is here similar to that of the bacteria, simple division into daughter cells which grow to full size and are then ready to repeat the process. Amoeba is much larger than the hay bacillus, being in diameter about one two hundredth of an inch.

Another representative protozoan is shown in figure 4. This organism, of about the same size as Amoeba, is found parasitic in the digestive tracts of certain marine animals. A well-marked nucleus is present, and one end of the cell is specially differentiated for adhering to the

Figure 2. Forms of Bacteria

wall of the alimentary canal. With this class of protozoa there appears, however, a complicated life-cycle or life-history. Certain processes set in, which result in the breaking up of the organism with the formation of considerable numbers of small spore-like bodies. These "sporozoites," when finally liberated, enter the wall of the alimentary canal at new points, undergo a developmental stage therein,

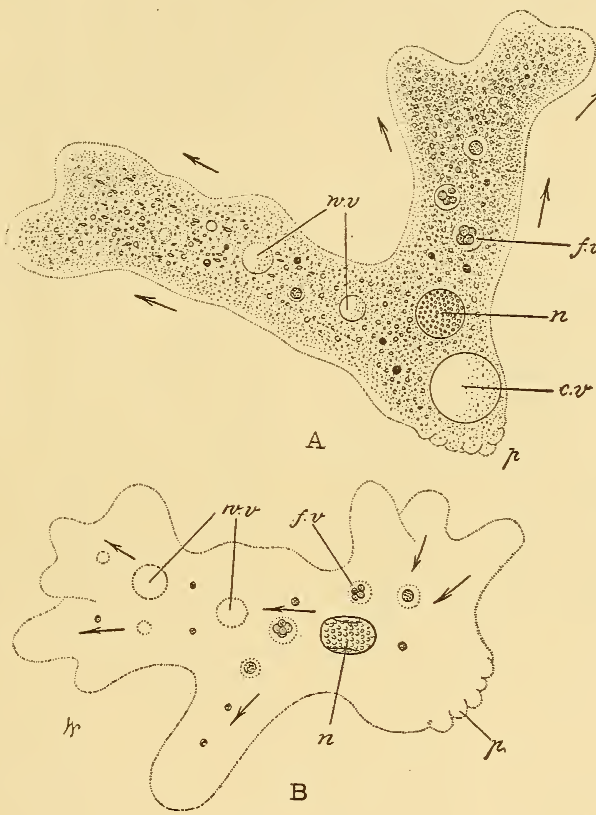


Figure 3

Amoeba Proteus,—from life, magnified 300 times. The arrows indicate the direction of the protoplasmic currents; *n*, nucleus; *c. v*, contractile vacuole; *f. v*, food-vacuole; *w. v*, water-vacuole. A shows the texture of the protoplasm. B is an outline of the same individual four minutes later; the upward currents at the right of Fig. A have stopped, reversed, and the main flow is now towards the left.

and finally emerge again into the intestine as the original attached form. Compared with the hay bacillus and Amoeba this is assuredly an involved life-cycle.

Euglena, typical of another group of the protozoa, is shown in figure 5. This organism is again of a size with Amoeba, and possesses a flagellum similar to those found among the bacteria. For an animal it has the surprising characteristic of possessing chlorophyl, the green coloring matter of plants. With its chlorophyl it can utilize sunlight, carbon-dioxide and water to form starch, distinctly a plant characteristic. The tiny red "eye spot," bordering on the contractile vacuole, is supposed to be sensitive to light. This microbe is free swimming by means of its flagellum, and is one of the most interesting and beautiful of all protozoa.

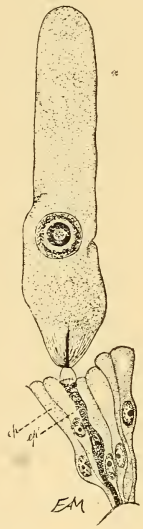


Figure 4
Trophozoite of *Lankesteria ascidiae* attached to an epithelial cell (ep'), which is withered and apparently destroyed by it, ep, normal epithelial cells.

We come finally to still another class of these organisms, characterized by the possession of many small lashing hairs—shorter and stiffer than flagella, and termed cilia. Paramoecium, the so-called "slipper" animalcule, which sometimes grows so large as to be discernible to the unaided eye, is a good example. Reference to figure 6 shows not only that this organism is thoroughly covered with fine cilia, but that it exhibits, for a single cell, a surprising amount of differentiation. A distinct gullet for the entrance of food is provided; there is a complicated system of vacuoles; waste products are expelled at a definite point; and there is even a separation and specialization of the nuclear material. The beginnings of a process of sexual reproduction are also illustrated. While the organism ordinarily reproduces by a simple transverse division analogous to that obtaining among the bacteria, it has been observed that under certain conditions two individuals will come into intimate contact and exchange nuclear material. This process is called conjugation, and forecasts the higher sexual process of union of specialized male and female elements. Experiments have been carried on to determine whether conjugation must alternate with the regular splitting division at definite intervals, but while some observers have found this to be seemingly the case, others have carried specimens through as many as two thousand successive divisions without a suggestion of a halt. The theory has accordingly been advanced that these organisms are in a sense immortal, never aging and never requiring the introduction of new elements to their protoplasm.

Sufficient has now been said to indicate that there are well-marked differences between the two great groups of microbes known as bacteria and protozoa. We have seen that as a group the protozoa exceed the bacteria in size, complexity, and variation of type. But we have also seen that some protozoa—as Euglena, possess characteristics generally recognized as distinctively vegetable. And, on the other hand, the bacteria possess important characteristics essentially animal. Evidently the matter is not as simple as would be signified by our original line of separation into animals and plants. And if we examine the matter closely we see that the three great criteria which are generally taken as distingushing plants from animals,—the possession of chlorophyl and the resulting simple food requirements, the cellulose cell wall, and the lack of movement in the plant body, are not met in the case of the bacteria. What then is the justification of our original distinction?

The answer to this question is found in a study of the relationships of the two groups to the other plants and animals. It is not a matter of applying to the forms under consideration clear-cut tests as to their animal or vegetable nature, but rather a matter of considering what other groups of organisms they most closely resemble. The bacteria, for example,

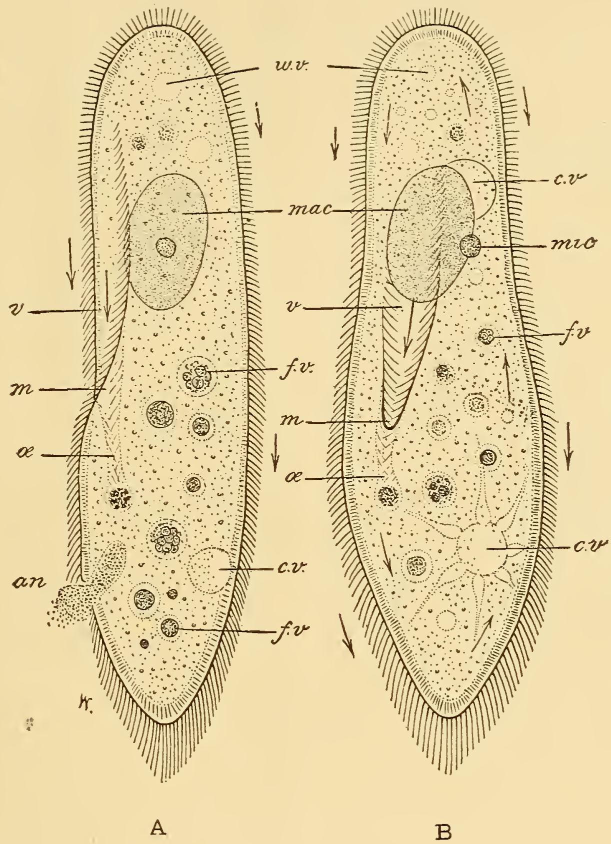


Figure 6

Paramoecium caudatum. A, from the left side, showing the anal spot; B, from the ventral side, showing the vestibule *en face;* arrows inside the body indicate the direction of protoplasmic currents, those outside the direction of water-currents caused by the cilia.

an, anal spot; *c. v.*, contractile vacuoles; *fv*, food vacuoles; *w. v*, water vacuoles; *m*, mouth; *mac*, macronucleus; *mic*, micronucleus; *oe*, oesophagus; *v*, vestibule. The anterior end is directed upwards.

despite several pronounced animal characteristics, seem to be linked closer to the blue-green algae, which are undoubted plants, than to any other group. Accordingly we are disposed to place them in the vegetable kingdom. The truth is that as we go lower in both kingdoms the lines of descent finally converge into a region of general similarity and uncertainty. Haeckel, the great German zoologist, has even suggested that instead of recognizing two separate groups of animal and plant microbes, we should see them combined into one large group to which he would give the name protista, or first animals. This plan, though apparently offering simplicity, seems to disregard real distinctions, and to leave us still with the old problem of setting up boundary lines, now around the new group.

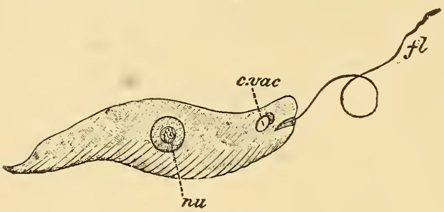


Figure 5
Englena. *c. vac,* contractile vacuole; *nu,* nucleus; *fl,* flagellum

A good working understanding of the situation may be gained from an examination of Figure 7. The arrows show the lines of ascending relationship and evolution from the lower to the higher animals and plants. At the foot of the scale we have on one hand the protozoa, on the other the bacteria. Both these groups are shown as overlapping a little into the opposite kingdom, and the dotted line between them indicates their interrelation. We may conclude that these are our simplest forms of life, microscopic and unicellular; the protozoa, on the whole, seeming to be linked more closely with the animals, the bacteria with the plants.

WONDERFUL MOVING PICTURES

In an article on motion pictures in a recent number of *McClure's Magazine* the author states that Dr. Comandon, a French scientist, has already shown what the combination of microscope and moving-picture camera can achieve in physiology and bacteriology. For the first time, he has given the world a picture of the blood coursing through the veins. He has likewise photographed one of the greatest medical discoveries of the age—the action of the white corpuscles of the blood which is known as phagocytosis. The discovery of this phenomenon is the thing that will immortalize the name of Metchnikoff. Metchnikoff discovered that the white corpuscles protect the blood, and consequently the body, from injurious foreign substances. They are the body's scavengers, or guardsmen. If any foreign substance enters the body, these white corpuscles, or phagocytes (cell-eaters), as Metchnikoff calls them, at once surround and absorb it. Their chief function is to protect us against bacterial diseases. If typhoid germs get into the blood stream, the white corpuscles immediately begin devouring them. If they succeed, we escape the sickness; if they fail, then we are forced to take to our beds.

When Metchnikoff first announced this discovery, scientific men were skeptical, though now they generally accept it. If there are any doubters left, the moving-picture machine can satisfy them. For, on an enormously magnified scale, Dr. Comandon has shown the phenomenon of phagocytosis in actual operation. What Metchnikoff, in the course of a lifetime, painfully worked out with the microscope, appears on the screen with all the realism of a dog fight.

A patient and ingenious Englishman, Mr. F. Percy Smith, has performed similar marvels with plant and insect life. He has succeeded in producing a film that shows a flower developing from seed to blossom. One of his most popular achievements is a moving picture of a chicken hatching from the egg. An Italian has completely cinematographed the development of a butterfly from a caterpillar; he even filmed the supreme moment of its emergence from the chrysalis.

MOSQUITOES AND THEIR EXTERMINATION*

THE LIFE HISTORY OF MOSQUITOES AND THE METHODS OF SUCCESSFULLY WAGING A WAR OF EXTERMINATION AGAINST THEM

BY WILLIAM LYMAN UNDERWOOD

The statement has been frequently made of late that there is no more reason why we should suffer from mosquitoes than there is that we should allow rats and mice to continually annoy us, and this statement is in a measure true. Rats and mice are to a great extent effectively held in check, for we have become accustomed to them and their habits, and we know how to deal with them. Were it not for the fact that a constant warfare is being waged against them, they would soon overrun our houses and make life unbearable.

In order to fight the mosquitoes successfully it is important that every one should take an interest in the popular uprising against this insect pest. And now that it is known that, besides being a nuisance, mosquitoes may be a menace to the health of the community, it is equally necessary that every one should become familiar with all that pertains to their life history so that the war against them may be successfully and intelligently carried on. Notwithstanding all that has been written on the subject of mosquitoes during the last year or two, the majority of people still know but little about them.

It is the purpose of this article to state, in as simple a manner as possible, the facts that are now known regarding mosquitoes and how to deal with these pests, and it is hoped that this information may help to secure a more general coöperation in the work of mosquito extermination.

Few people realize that there are a great many different kinds of mosquitoes. Some three hundred species have already been described, and here in the United States we have about fifty species, belonging to nine different genera. The most common of these genera in the northern states are *Anopheles*, the malarial, and *Culex*, the ordinary, mosquito. Of the former there are two species and of the latter at least fifteen.

Only these two genera and the methods for their extermination will be especially considered, and as these methods may also be successfully applied to the other kinds of mosquitoes, no detailed description of the others need be given.

It is commonly and quite naturally thought that mosquitoes breed in wet grass, as they are often seen to rise from it in clouds when disturbed, particularly in the early morning and evening. They have not bred there, however, but have merely sought the shelter of the grass where they can be protected from the wind. The moisture of the dew upon the grass also furnishes an attraction for them and they always prefer damp rather than dry places.

Another popular theory is that mosquitoes will breed *only* in foul or stagnant water. This is also a mistaken idea though they often do breed in such water, not because it is impure or stagnant, however, but because these places are usually quiet and here the female can deposit her eggs undisturbed.

It is commonly supposed that mosquitoes do not breed in salt water, but the "Mosquito Investigations" of Prof. John B. Smith of New Jersey, which were published in the New Jersey Agricultural College Experiment Station Report of November, 1902, show that the larvæ of *Culex sollicitans*, the "salt marsh mosquito," not only prefer salt or brackish

*Illustrated with photographs from life by the author. The illustrations and photographs are copyrighted.

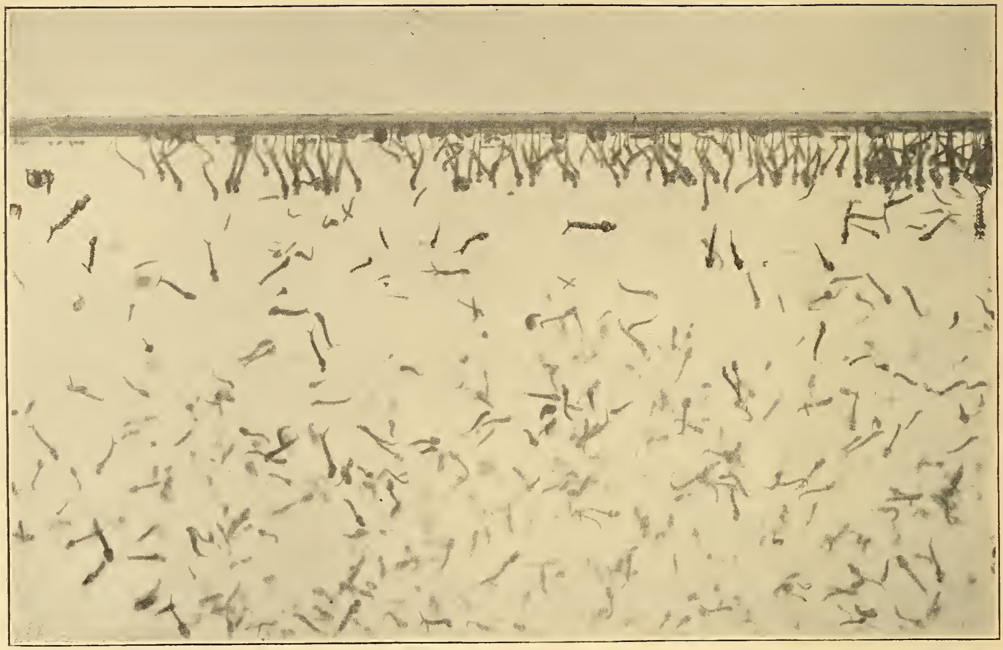


Fig. 1. Mosquito "wigglers"—larvæ and pupæ—in the water. Life size

water, but are seldom found in pools where the water is strictly fresh, and, contrary to the usual custom, this mosquito lays its eggs upon the soil of marsh or meadow land. There the eggs remain until the advent of an unusually high tide. Then after a few hours when the water has covered them, the infant larvæ make their appearance.

It is very generally believed that mosquitoes bite but once and then die. This is sometimes so; but, unless they are killed in the act of biting, they usually live to bite again. The female mosquito (for it is only the female that attacks human beings) bites many times. It is owing to this fact that *Anopheles* is able to convey the germs of malarial fever from person to person. When biting any one who is afflicted with malaria, the insect draws in with the blood the germs of the disease, which it afterwards carries on into the blood of another victim. The vast majority of mosquitoes never get human blood for food. In its absence they live upon the blood of birds and other animals, and when these are not to be found, upon the juices of young and tender plants.

It is not known just how long mosquitoes can live, but their average life is much longer than is ordinarily supposed. Thousands of them live through winter hibernating or asleep in dark places in barns or house cellars. In sparsely settled localities, where they cannot find such places for shelter, they live through the winter in hollow trees, in caves and holes under upturned trees; and, even though the temperature may fall far below freezing, they are not winter-killed, but on the approach of warm weather become active again. Mosquitoes are frequently seen flying about in the woods before the snow has wholly left the ground.

Mosquitoes cannot develop or come to maturity without water in which to live during the first weeks of their "wiggler" existence.

A mosquito's life is divided into four stages—the egg, the larva, the pupa and the adult insect. In the larval and pupal stages, mosquitoes are more commonly known as "wigglers" (see fig. 1). Both

Anopheles, the malarial, and *Culex*, the common, mosquito larvæ are present in this picture. Mosquito "wigglers" may frequently be found in rain-water barrels in as large numbers as are seen in this photograph. The female mosquito lays from one hundred and fifty to four hundred eggs upon the surface of some quiet water, and in a day or two these eggs develop into the larval or second stage.

It will be noticed that *Culex* hangs with its head down, and from its tail upward to the surface of the water extends a small tube. Through this tube it breathes. *Anopheles* rests just beneath and parallel to the surface of the water, and its breathing tube is much shorter than that of *Culex*. These resting positions are quite different, and each is characteristic of its kind. Except when disturbed, *Anopheles* is generally to be found at the surface, breathing and feeding in this position. *Culex*, on the other hand, comes to the surface only occasionally to breathe. It stays below the water for the greater part of the time, and is often found feeding from the bottom.

At the end of a few days the larvæ change into the pupal or third stage (see fig. 2). To the left is seen the larval skin out of which this pupa has just come. The difference between *Culex* and *Anopheles* in this, the final stage of "wiggler" existence, is very slight. Both now live at the surface of the water, and they breathe through two funnel-shaped tubes situated one on each side of the thorax, or "head." Unless disturbed, they remain motionless in this position at the surface until the time comes when, as adult mosquitoes, they leave the water. This is the critical period of a mosquito's life; for, should the surface of the water be disturbed at this time, the insect would be upset and drowned. It takes about seven minutes from the time when the skin along the back of the pupa begins to split until the full-grown mosquito comes forth and in a few minutes is ready to fly away. A mosquito never grows any larger after this change.

The length of time required to pass from the egg to the adult insect varies from ten days to three weeks, according to the temperature. Warm weather hastens their development, while low temperature checks it. The "wigglers" of some species of mosquitoes live through the coldest weather of our northern winters unharmed, ready, when the first warm days of spring have come, to complete their natural changes.

Mosquitoes' eggs are so very small that ordinarily they remain unnoticed, but nearly every one who lives in the country is familiar with the little "wigglers" that are often seen squirming up and down in rain-water barrels. Few people know that these little fellows are connected in any way with mosquitoes, but it is a very easy matter to prove that they are. Let any one who doubts this fact dip up a few in a glass jar or tumbler and place them in the house, where they can be frequently looked at. Seeing is believing; and after a full-grown mosquito has once been seen to come forth from a pupa (which is the

Fig. 2. A pupa, the third stage in a mosquito's life. Three and one-half times as large as life

last stage of the "wiggler"), there can no longer be any question as to what these "wigglers" really are.

Most of the mosquitoes that annoy us are bred near by, often, though unknown to us, in our own dooryards. Any water that is accessible to mosquitoes and whose surface is undisturbed by winds or rapid currents furnishes a breeding-place for them, and "wigglers" may often be found in water standing in old

tin cans or bottles, in rain-water barrels, in pools in the rocks, in roof or street gutters that are not properly drained, in cesspools or in catch-basins, in fact, in any place that will hold water for a week or two, no matter how small the quantity, even if only a few teaspoonfuls.

Since we know that without water mosquitoes in their first stages cannot exist, it naturally follows that all standing water should be done away with or treated in such a manner that "wigglers" cannot live in it nor mosquitoes get to it to lay their eggs. To this end all cans, bottles, and every discarded utensil that will hold water should be removed. All stagnant pools, where it is possible to do so, should be drained or filled up. Cisterns, rain-water barrels and cesspools should be screened or otherwise covered to prevent the adult insects from having access to them. Where it is not practicable to fill, drain, or screen the places that are suitable for mosquitoes to breed in, the surface of the water may be covered with kerosene oil. This oil, when spread over the water, prevents the "wigglers" from getting air when they come to the surface to breathe, and so kills them (see figs. 3 and 4).

In figure 3, a "wiggler" is seen trying to get air, vainly thrusting its breathing tube up into the film of kerosene.

In figure 4, the upper "wiggler" is grasping its breathing tube in its mouth, apparently trying to pull off the small particles of kerosene with which the tube has been clogged. The "wigglers" upon the bottom have been suffocated and have given up the fight.

An ounce (two tablespoonfuls) of kerosene will spread over fifteen square feet of water surface, forming a film thick enough to kill all the "wigglers" that are beneath it. Kerosene of a cheap quality, known as high test light fuel oil, is preferable for this purpose. It can usually be bought at eight cents a gallon. If oil of this quality is not available, ordinary kerosene will answer the purpose. It should be applied as often as once in two weeks, for by that time the previous application will have evaporated. A sufficient quantity should be used, in the proportions named, to cover completely any place that may need treatment.

Any one who is ill with malaria or yellow fever should be carefully protected from mosquitoes, for, should a person be bitten by an *Anopheles*, the malarial mosquito, or *Stegomyia fasciata*, the yellow fever mosquito, at this time, there would be great danger that the insects might fly away and bite some one else and thus spread these diseases. Screens for both doors and windows form the best protection against mosquitoes at all

Fig. 3. Three times as large as life

times; but it often happens that the insects get into our houses, even though they are thoroughly screened, generally through some door or window that has been left open by mistake, or they may gain an entrance by coming down an unused chimney if the flue is allowed to remain open during the summer time. A house or a room may be cleared of mosquitoes by burning pyrethrum powder and allowing the smoke, which is not at all offensive to most people, thoroughly to fill the room that is under treatment. This smoke kills or so stupefies the insects that they will not bite. Pyrethrum powder is a preparation of the plant

Pyrethrum roseum, and is sometimes sold as Persian Insect Powder or Dalmatian Powder; it can be bought at any drug store for about thirty-five cents a pound.

Fig. 4. Three times as large as life

It is a very fine, light powder; and an ounce of it will go a long way, making a large volume of smoke. A pyrethrum smudge or smoke may be started by covering a live coal, taken from the kitchen stove, with the powder, first placing the coal upon a small shovel, so that it may be moved about conveniently without danger of setting anything on fire. The pyrethrum will quickly begin to smoulder and give off a dense smoke. All that is now necessary is to add from time to time a pinch of the powder as occasion requires, merely keeping the smouldering ashes covered so that they will give off a smoke. People are frequently annoyed and sometimes driven into their houses on summer evenings by the persistent attacks of mosquitoes. On such occasions, pyrethrum powder can often be used to advantage: and the smoke from a small quantity of the powder kept smouldering upon the piazza will drive away most, if not all, of the pests, thus making it possible to enjoy an evening out of doors in comfort, when otherwise life would be unbearable except behind the protection of screens.

The *Anopheles*, or malarial mosquitoes, though not very common (see figs. 5 and 6), are breeding quite abundantly in many parts of this country; and by referring to the accompanying photographs, particularly the ones in profile, it will be seen that there is quite a difference between the malarial and the common, or *Culex*, mosquitoes.

They may easily be distinguished from the common or *Culex* family of mosquitoes by the spots upon their wings, and also by the position which they take when at rest (see fig. 6).

Notice the angle at which the insect shown in figure 6 stands out from the wall. It will also be seen that the proboscis, or "stinger," and the body of *Anopheles* form a straight line, while the *Culex* is rather humpbacked. The other *Anopheles, maculipennis*, does not stand out from the wall at quite such an angle as does *punctipennis;* but like the latter its proboscis and body form a straight line, and the angle formed by the insect when at rest is much greater than that of the *Culex*.

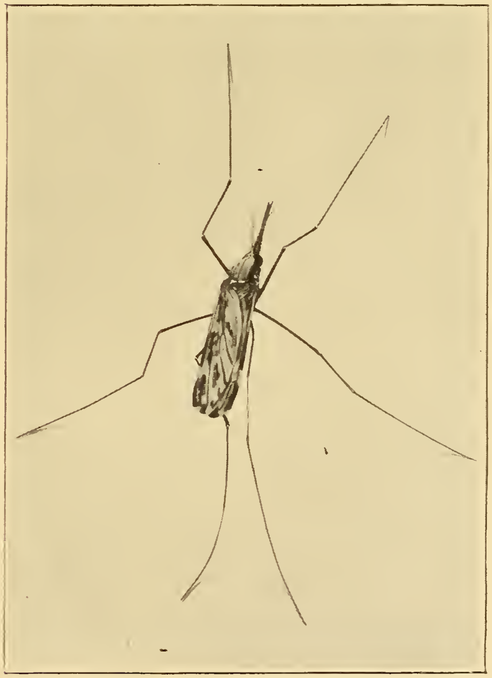


Fig. 5. *Anopheles punctipennis* (female). Three times as large as life

The male mosquito never bites. He may be easily distinguished by his large and feathered antennæ and palpi, which are very much more prominent than those of the female.

There is another mosquito, *Stegomyia fasciata*, which in form and habits closely

Fig. 6. Profile of *Anopheles punctipennis* (female). Six times as large as life. Showing the characteristic resting position of this mosquito

resembles *Culex*, in which genus, until quite recently, it was classed. *Stegomyia fasciata* is the yellow fever mosquito, and it inhabits only the warmer portions of this country. It is common in most of our southern states and is seldom seen north of the Carolinas. It is easily distinguished from other mosquitoes by the conspicuous silvery white stripes upon its thorax and abdomen, and by the white bands upon its legs.

Fortunately for mankind, nature herself provides many energetic workers which are constantly doing their part towards holding in check these insect pests. Foremost among these natural enemies are many of the insectivorous birds, which daily destroy many thousands of mosquitoes. The swallows, the fly-catchers, the night-hawks and the whip-poor-wills, all are insect exterminators, whose good work in this connection is seldom taken into account. The bat is also an efficient mosquito hunter; so, too, are the dragon flies which frequent the shores of ponds and pools where mosquitoes breed.

Besides these enemies of the adult mosquito, which may properly be called their "foes of the air," mosquitoes have other adversaries which destroy them in their early stages. These may be termed their "foes of the water."

It often happens that we can find no "wigglers" in small ponds in which we would naturally expect to find mosquitoes breeding. In such ponds the presence of fish may account for the absence of mosquitoes. Their larvæ furnish food for many species of our smaller fishes, and by them myriads of mosquitoes are annually destroyed. Goldfish are particularly fond of mosquito "wigglers," and the pair of fish in the illustration (see fig. 7) were seen to eat ninety-eight "wigglers" in four minutes. Goldfish will live and multiply in almost any small and shallow pond in this vicinity, where the water is warm. They are perfectly hardy and will thrive just as well and perhaps better in stagnant water than they will in flowing streams.

The "top minnow," the roach, the sunfish or "pumpkin seed" and even the sluggish horn-pout all play an important part in reducing the numbers of mosquito "wigglers." Besides the fishes, there are other "foes of the water" that prey upon mosquito larvæ. Many of the predatory water bugs feed upon them. Prof. J. B. Smith, in the report previously referred to, says that "among these predatory insects which abound in shallow permanent bodies of water wherever

Fig. 7. Goldfish eating mosquito larvæ. Life size. These two fish were seen to eat ninety-eight "wigglers" in four minutes. They always fed upon mosquito larvæ when they could get them in preference to prepared goldfish food

there is vegetation, the water boatman (*Corisa* and *Notonecta*), the water striders or skate bugs (*Hydrobatidæ*) and the water scorpions (*Nepidæ*, *Belostomatidæ*) deserve mention." He also speaks of the "water tiger," the larva of the large water beetle (*Dytiscus*), and tells of its ability to clear *Culex* larvæ from pools of water.

In this connection a brief description of a newly discovered mosquito,* to which has been given the name *Eucorethra underwoodi*, should be of interest, since it has been found that their larvæ devour the wigglers of other mosquitoes, and unlike other mosquitoes, the adult female insect does not bite. As the proboscis of this insect is so formed that it cannot puncture the skin, it should not perhaps be called a true mosquito, though it has been classed as one, since it belongs to the family Culicidæ.

The larvæ of this insect were found by the author in the Maine woods in the eastern section of Penobscot County, and were discovered in a spring of water from which a crew of lumbermen were getting their water supply. A few days later, other larvæ of the same species were found in a similar spring about eight miles distant, though in this case, as the spring was not in use, its surface was covered with a coating of ice an inch thick. The temperature of the water at the bottom (it was about two feet deep) was 42° F.

At first sight this larva would be taken for an *Anopheles* of extraordinary size, as it is of the same general shape, and when the water was cleared of ice, it lay just beneath and parallel to the surface, breathing through a short respiratory

*Under the title "A New Mosquito" a description of this mosquito appeared in *Science*, New Series, Vol. XVIII., No. 449.

siphon, as is characteristic of the larvæ of *Anopheles*. In this spring a barrel had been sunk and in the fifty gallons, or thereabouts, of water which it contained there were twenty-five larvæ. They were all of about the same size—12 to 14 mm. long—and almost black in color. All were secured and taken into camp for further investigation.

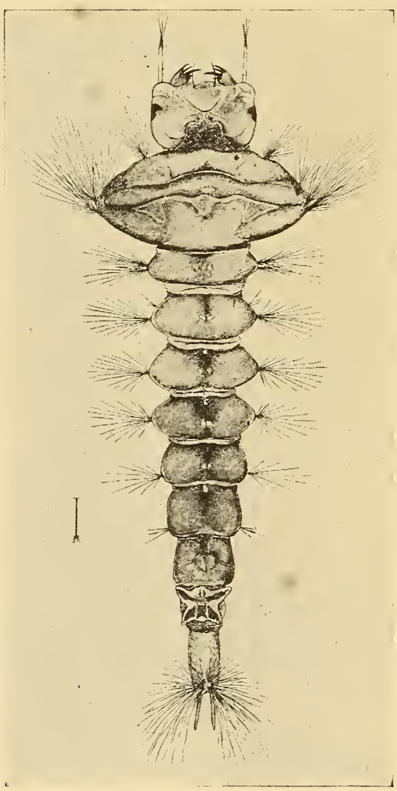


Fig. 8. Larva *Eucorethra underwoodi*. Dorsal view

Close observation of the larvæ showed that besides being much larger (12–14 mm. long instead of 5–7 mm.) they differed in many other particulars from the larvæ of *Anopheles* (see fig. 8). In proportion to the rest of its body, its head is larger than the head of *Anopheles*. It does not turn its head upside down when feeding as does *Anopheles*. Its mandibles are strikingly large and powerful and are prominently toothed. It lacks the frontal tufts or brushes which are conspicuously present in *Anopheles*, and its antennæ, which extend directly forward parallel with the sides of the head, are much longer and more slender, and are tipped each with three hairs of equal size. The thorax is broadly elliptical and is much wider in comparison with its abdominal segments than is the thorax of *Anopheles*. The sides of the thorax and the abdominal segments bear fan-shaped tufts of hairs, not plumosed as in *Anopheles*. The tufts on the last segments, both dorsal and ventral are more profuse in *Eucorethra* than in *Anopheles*, especially the ventral tuft which in *Eucorethra* occupies nearly the whole segment. Only two anal papillæ are present, while *Anopheles* has four.

A few days before the author returned to Boston, several larvæ died and three changed to pupæ. The pupa resembles that of *Culex* rather than of *Anopheles* and its respiratory siphons are of the same shape as those of *Culex*. When stretched out at full length, the pupa measures ten mm.

On reaching home, the new wigglers, eighteen in number, were put into a quart jar which was placed near a window where it would receive the sunlight for two hours each morning. The temperature of the water now averaged about 70° F., and with this change the larvæ developed a new trait—they began to eat each other up. The act was witnessed on several occasions. The larva would grasp its adversary just forward of the respiratory siphon with its powerful mouth parts, and working the tail in first it would gradually swallow its victim, shaking it now and then as a terrier would shake a rat.

After losing many of the insects in this way, those that remained were separated, and each individual was placed in a small bottle by itself. Eventually, I succeeded in rearing a number of males and females. The pupal stage of this insect varies from five days and ninehours to six days and the hours. The adult (see fig. 9) resembles *Anopheles* in having maculated or spotted wings, but is much larger and measures

eleven millimeters in length. Its mouth parts, however, are not adapted for biting. A full description of the imago is soon to be recorded by Mr. D. W. Coquillett, of the National Museum, by whom the name above mentioned was given.

During a later visit to Maine, a large number of larvæ of *Eucorethra* were taken from the spring where the barrel had been sunk. It was noticeable that

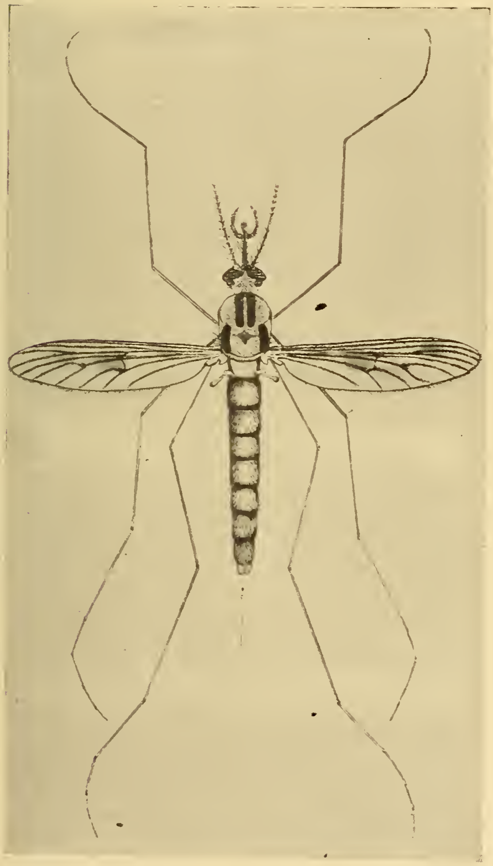


Fig. 9. *Eucorethra underwoodi.* Coquillett MS. Original drawing

larvæ of other kinds of mosquitoes were absent, although the adults were very numerous in the immediate vicinity.

The absence of other mosquito larvæ was accounted for when later it was discovered that the larvæ of *Eucorethra* fed upon the larvæ of other mosquitoes, eating them apparently with great relish. On several occasions fourteen *Eucorethra* larvæ ate, during the night, sixty *Culex* larvæ out of the seventy that had been placed in the water with them. When eating the larvæ of mosquitoes smaller than themselves, the victim is caught, shaken violently a few times, and swallowed in a few seconds in very much the same way that a pickerel would catch and swallow a smaller fish.

Although myriads of mosquitoes are destroyed by the natural enemies which have been mentioned, man should be the most destructive foe of these insects. There is no doubt that the mosquito pest may be very largely abated by the employment of scientific methods for causing its destruction in the early stages of its development.

While it is the duty of boards of health to recognize mosquitoes as active agencies for the dissemination of certain diseases and to take such measures as are possible for their extermination, the work can never be effectively done until the people of each community are fully informed in regard to the life history of the mosquito so that all may cooperate ntelligently to secure its destruction.

A NEW METHOD OF PLATING

The Marino plating process permits electrodeposits on china and other nonconductors. The article to be plated, say, a china teapot, has its surface roughened by a sand blast and is then painted with a paste consisting of a mixture of the chloride, or other salt, of the metal to be deposited and hydorfluoric acid. This forms a preparative surface on which metal can be deposited from an electrolytic bath by the usual means. A thick plate of metal is obtained, which can be polished and worked, while at the same time the china interior is strengthened. This arrangement, it is claimed, also makes the cold galvanizing of such articles as screws, chains and other machine parts possible at a less cost than the present process.

THE ELEMENTS OF FATIGUE

THE RELATIVE SHARE OF MUSCULAR AND NERVOUS ELEMENTS IN ITS PRODUCTION. —A NEW EMPHASIS UPON SENSORY FACTORS IN ITS DEVELOPMENT.

BY PERCY G. STILES

No fact of life is more familiar than the development of fatigue. We anticipate that the vigorous and continued employment of a set of muscles will lead to sensations of discomfort, then of difficult effort, and, finally, of utter inability to continue the action. We expect to see parallel objective conditions: progressive loss of speed, force, and certainty of movement. The physiological changes which attend this decline of efficiency are far more complex than would at first be assumed. To enumerate them and to assign to each its proportionate share of the total effect has been a fascinating task and it is one which has not yet been completed.

The evolution of energy by a contracting muscle is limited by the store of available fuel. This is as strictly true for the living tissue as for a locomotive. In some respects the muscle is more like a machine-gun with a definite supply of cartridges. Either analogy is quite faulty but if we rely on such comparisons provisionally we shall be inclined to infer that fatigue indicates a dwindling stock of fuel or ammunition. We must not forget, however, that in the normal body fresh supplies are offered to the working organs by the passing blood-stream. Exhaustion is postponed accordingly and may not threaten at all if the degree of activity is moderate. Our best illustration of such renewal is found in the heart; the diaphragm approximates the same condition since it probably never fails to bear a part in the inspiratory movements.

Consumption of fuel in living or lifeless surroundings is attended with the generation of oxidized products. If such compounds are not promptly removed they will impede the fundamental chemical reactions of the contracting muscle. Fatigue, then, may be brought on by inadequate removal of wastes as well as by a shortage of energetic material. It becomes evident that an abundant circulation increases muscular endurance not only by providing fresh fuel but by dispersing the end-products—and perhaps the by-products—of the decomposition process. In fact it is commonly held that the failure of contraction usually occurs as a result of an accumulation of such substances and becomes absolute while much fuel yet remains in the cells. This conception makes fatigue an intoxication rather than an exhaustion and is in accord with the experience that fatigue of certain muscles spreads somewhat to others not used.

Laboratory experiments are easily devised which shall single out for observation the facts of true, localized muscular fatigue. In life the mechanism at work includes nervous as well as muscular elements and we have to consider the possible susceptibility of the former as well as the latter to the depressing consequences of their own activity. The resistance to fatigue exhibited by a man performing voluntary movements is not necessarily a measure of his muscular resources; it may be limited by conditions arising in his nervous system. It is of the utmost interest to discover the weakest link in the chain employed. We cannot make much progress in this direction until we shall have pictured the related parts which constitute a simple neuro-muscular mechanism.

A muscle is composed of a host of associated fibres of microscopic diameter. Each of these may be regarded as a muscle in miniature. It is a thread-like af-

fair averaging an inch or more in length. About midway between its extremities it is tapped by a filament derived from the nerve governing the muscle in question. The muscle-fibre is a chemical engine; the function of the connected nerve-fibre is to throw it into action. One is reminded of the electric wires by which a torpedo is exploded. Where the nerve-substance seems to blend with that of the contractile muscle-protoplasm there appears to be an intervening structure differing from either. This junction is referred to as the motor end-plate.

If we could trace the course of a selected nerve-fibre back from an end-plate to its place of origin we should be led within the confines of the central nervous system. If the fibre were one which terminated in a leg muscle it would be found to spring from a curiously branched cell in the gray matter of the spinal cord. The same would be true of a fibre terminating in the arm but in this case the cord-cell would be higher up. The muscles of the head are presided over by cells in the brain. Still retaining the crude analogy of the torpedo and its connections we find the nerve-cell standing for the battery which generates the current used to bring about the explosion. Under the terms of this comparison the end-plate is a priming appliance to transmit the effect of the nerve impulse to the unstable substance of the muscle. Any such attempt to compare the living fabric with artificial systems does violence to detail and must be regarded as symbolic rather than literal in character.

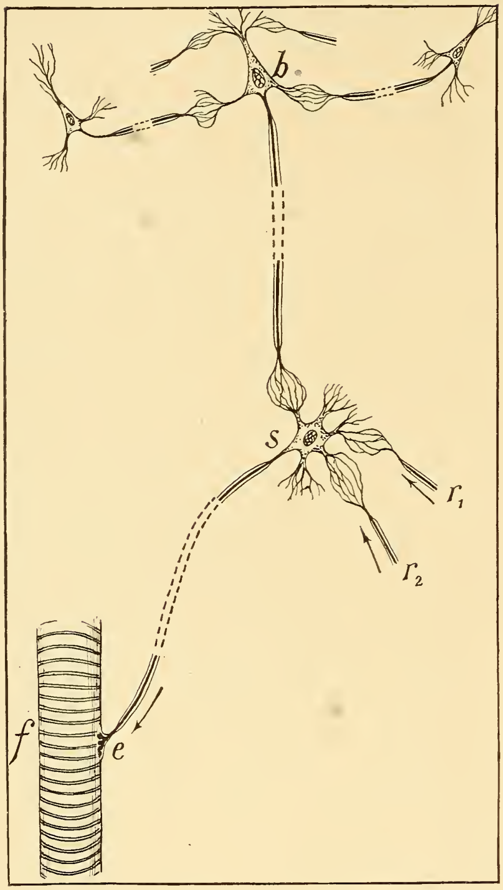
In the light of what has been said it will appear that fatigue may conceivably result (a) from changes in the working muscle, (b) from declining efficiency of the end-plate, (c) from alterations in the nerve-fibre, (d) from the decomposition processes in the nerve-cell. One of these theoretical possibilities may be ruled out. This is (c) in the series above; there is no doubt that of the several elements the nerve-fibre is the least subject to fatigue. Among the others it is commonly held that the end-plate is particularly liable to deterioration and that it is the diminishing utility of this transmitter which practically cripples a muscle after a certain period of vigorous use. It has been suggested that the end-plate bears a degree of resemblance to the safety fuse so often introduced in connection with electrical fixtures. This is to say that injury resulting from over-stimulation may be expected to fall upon this structure (which may be supposed to be easily renewed) and not to affect so readily the elaborately organized protoplasm of the muscle-fibre or the nerve-cell.

Most discussions of the subject of fatigue have been limited to the elementary mechanism just sketched. But when we are dealing with the intact organism and not with laboratory preparations there are additional matters to be considered. The nerve-cell which is the immediate source of excitation is not self-stimulated. The responsibility for its discharges is to be referred back to the activity of other cells so placed as to play upon it. In the case of those contractions which we regard as voluntary the cord-cells are known to be spurred to their work by cerebral cells. As soon as we include this new order of nervous units we find that we have to recognize further possibilities in the distribution of fatigue. We are called upon not only to estimate the extent to which true brain fatigue may figure in the observed result but to ascertain also whether the point of functional union between one nervous element and another may become impaired for its work as may the end-plate between nerve and muscle.

The "point of functional union" just mentioned is covered by the convenient word "synapse." The fact has lately been established that the synapse has to be reckoned with in any full treatment of the incidence of fatigue. It is very probably a link of inferior endurance and by its early refusal to conduct stimuli it may be assumed to protect the adjacent cells from excessive wear and tear. The symbol of the safety fuse is at least as legitimate for the synapse as for the end-plate.

We have traced the causation of voluntary muscular movement back from the muscle to the motor nerve-cells di-

rectly in connection with it and thence to cells of higher position in the nervous system. It is found to be difficult to account for the activity of these higher



A simple neuro-muscular mechanism. (f) is a muscle-fibre. (e) is the end-plate through which it is stimulated. (s) is the motor cell in the spinal cord which sends out the impulse. This cell is subject to excitation—or perhaps to restraint—through its several synapses. Of these three are shown fully developed: (r_1) and (r_2) are paths of approach for sensory impulses such as Forbes employed, the remaining path is from the cerebral cell (b). The efficiency of this brain-cell in typical 'voluntary' action is probably dependent upon the number of sources from which it is stimulated. Four of these are represented.

cells save on the assumption that they in their turn are goaded through synapses that place them in relation with still other working units in the brain. Whither are we led when we pursue as far as possible this shifting of responsibility for stimulation? Most authorities are agreed that we are obliged, in the last analysis, to conclude that the primary cause of the serial process is found in the influence of external conditions upon the receptors or sense-organs of the body. This is equivalent to saying that all muscular activity partakes very largely of the nature of reflex action. The psychological difficulties entailed cannot be dealt with here.

The emphasis lately placed upon the importance of the sensory side for efficient muscular performance has led to the question whether fatigue may not, in common experience, be due to changes on the route of the in-flowing as well as the out-flowing impulses which traverse the nervous system. We are compelled often to acknowledge that our fatigue is more accurately to be described as *disinclination* than as *incapacity*. To confess this is to express the belief that the motor mechanism still has power to work but that the sensory accompaniments have taken on a deterrent instead of a reinforcing character. We may conceive that the motor cells either in the brain or the cord—perhaps in both—are simultaneously prodded and restrained by different currents. The restraining or, technically, inhibitory influences become stronger with continued work while the positive stimulation is likely to flag.

Fatigue, when due to the fact that the inhibitory effect has become quite equal to the stimulation, will evidently disappear in part if new currents of an exciting sort can be supplied from without. This is exemplified by the power of emotional appeals, especially threats, to urge on a weary runner. Even more obviously it is the basis of the effect of blows. Yet the same principle may be recognized when the affective tone of the extra sensory application is wholly pleasant: for instance, in the postponement of fatigue for dancers whose whole environment encourages continued activity.

A reference in conclusion to a specific research will give coherence to much that has been said above. Alexander Forbes has shown (in cats) the following facts.[1]

[1] American Journal of Physiology, 1912, XXXI, 102.

A certain muscle is chosen for study and two sensory nerves are found, either of which can be employed to secure a reflex contraction of the muscle. One of these is stimulated persistently until the reflex fails. Stimulation applied to the other sensory path, immediately after, produces a vigorous reflex. What seemed to be total exhaustion is shown to be merely a failure of one particular inward route. Forbes locates the fatigue in his experiments in certain synapses between sensory and motor units of the spinal cord. He has simplified the conditions of his trials by eliminating the brain entirely and observing reflexes which are mediated through the cord alone.

Let us consider in what respects the human system is different at the end of a long day's walk from what it was in the morning. It doubtless presents many peculiarities which we have not hinted at. Altered secretory activities have influenced the composition of the blood; there has been an increase of lymph in many regions. The heart has been characteristically modified in its action. Without attempting to suggest other features we may summarize those which we have been discussing. The muscles contain less available fuel than they did. They are narcotized to some extent by their own chemical products. These products have been spread through the circulation and are very likely acting as depressants within the nervous system. The end-plates have suffered particularly and transmit with difficulty the impulses sent from the cord.

Fixing our attention upon the central axis itself we find that cellular fatigue there is a possibility but that exhausted synapses are more likely to be to blame for the sluggish reactions witnessed. Hence, to call out the last reserve of power, new means of sensory stimulation must be brought to bear. If our imagined subject is a tired soldier he may be carried along for a time under the sway of martial music. When that agency fails because its avenue of approach to the motor centers is choked, a pistol held to the head may compel him to continue his painful progress still longer. It becomes clear that if our fatigue were wholly a motor impairment, no fresh incentive to resist it could help at all. A playful trial of endurance would establish the same record as a struggle to escape impending death.

Note — One qualification may be necessary. The extensive nervous processes which accompany emotion may cause the extra formation of adrenalin and perhaps direct the metabolism in other ways to favor muscular performance. But this does not invalidate the truth that changes in the form of sensory stimulation may reveal stores of strength where apparent exhaustion prevailed.

FUTURE POWER AND HEAT

An editorial writer in the *Electrical World* predicts that the transportation of fuel is soon to cease and the transmission of electric power will take its place, and that the future maps of industrial lands will be covered with a net work of transmission lines which branch out from sources of power either situated at waterfalls or at coal mines.

The transmission of electric power has certainly changed industrial conditions in many countries, especially the Alpine ones of Europe, which are tending towards industrial pursuits now that the utilization of their numerous waterfalls to give electric power is possible.

It does not, however, seem likely that electricity would be used to any great extent in the heating of houses on account of its inefficiency, but the future will probably see the abolition of the domestic heating plant and the substitution of central stations which will distribute heat by means of pipes in the form of steam; in all probabilities, superheated. L. E. M.

A calculation has been made of the time that elapses before a drop of water evaporated on the surface returns to the ocean. The total volume of water brought annually to the sea is 1-3460 of the total contents of the ocean. A particle of water before evaporation has stayed in the ocean on an average 3460 years. Once evaporated, the drop becomes condensed in about ten days and is then speedily drawn back to its ancient home.

SOME INDUSTRIAL USES OF SUGAR

MANY IMPORTANT USES FOR SUGAR FOR OTHER THAN FOOD PURPOSES—GREAT DIVERSITY OF MANUFACTURES INTO WHICH IT ENTERS

BY GEORGE W. ROLFE

SUGAR,—using the term quite in the popular sense, meaning what the grocer calls sugar—is of enormous importance to mankind as food, its annual consumption of some 17,000,000 long tons is enough to give every inhabitant of the earth at least 20 lbs. Hence, the attention of most people is diverted from the numerous uses of this substance in many large industries, by no means alimentary.

M. Vivien has given a most informing paper on this subject in recent numbers of the "Bulletin de l'Association des Chimistes de Sucrérie et de Distillerie de France et des Colonies," the leading French sugar periodical. Vivien writes with special reference to conditions in France, his paper being a plea for the use of sugar as the cheapest form of a chemically pure carbohydrate, replacing in many cases glucose, starch and dextrin.

The French Government imposes an internal revenue tax on sugar and glucose products used as human food which makes the price of sugar about 12 cents per pound, but by a law similar to that which applies to alcohol in this country "denatured" sugar, that is, sugar to which some substance has been added to make it unfit for food, is exempt from taxation. As in alcohol denaturizing, the substance added is, if possible, some ingredient in the special process using the sugar.

In France, an excellent quality of sugar known as No. 3 white sugar and polarizing over 99 per cent. sells, when denatured, at a price equivalent to from 3 to 4 cents a pound, or about what the refiners pay here for raw sugar. This is lower than starch, glucose or dextrin sells in Europe.

It may be of interest to note some of the more important applications of this denatured sugar, bearing in mind that in this country at present market conditions molasses and starch products are more economical substitutes in some cases. Some of the industries which Vivien enumerates are large consumers of sugar in this country.

Sugar is a common ingredient of many compounds for removing and preventing boiler-scale. As these usually contain alkali, this is used as a denaturant. The shoe-blacking industry uses sugar and molasses to considerable extent. In Europe there seems to be a tendency to use blackings of this older type as less injurious to leather than the newer wax blackings, owing to the solvents used in the latter. These shoe-blackings are made by the carbonizing action of sulphuric acid on the sugar. The product is neutralized and other ingredients, added such as powdered boneblack, oil, ink, and sometimes glycerine.

Perhaps one of the industries of greatest present importance, both here and in France, is the manufacture of transparent soap. Originally, the English soaps were made by the costly process of dissolving the soap in alcohol, decanting the soap solution and recovering the alcohol by distillation. Later, glycerine was used as a solvent but this made the soap too sticky, so that it soiled the wrappers. The sugar soaps do not have this disadvantage. Hence, many tons of sugar are now used by soap manufacturers in this country as well as in Europe.

There are over thirty patents for explosives in which sugar is a component to the extent of from six to forty per cent. This use of sugar has been so important

in Germany that a special provision is made by that country for denaturizing sugar used in the manufacture of explosives, paraffine or similar oil being used.

In the color and dyeing industries, we find sugar used as a reducing agent in indigo and chrome work, as a base for the manufacture of organic chromium salts and as a vehicle or "filler" for solid aniline colors giving them an attractive appearance. In many cases this latter practice is carried to somewhat questionable lengths as some of these dyes contain over 90 per cent. of sugar.

So too, the European tanneries use large amounts of sugar in "filling" leather, (glucose being used in this country) and to some extent, in removing lime from hides in the "dehairing." This solvent action of sugar on lime and the easy recovery of the sugar by carbonation has suggested its use in several processes where it is desirable to remove excess of caustic lime from calcined minerals, such as phosphates, zinc or magnesium oxides and the like.

Tannin extracts are also "filled" with sugar, as they are on this side of the water, with glucose. Sugar is also used in several chrome tanning processes as a reducer and, as in dyeing, for making acetates and formiates.

Ordinary copying ink is made by the addition of 1 part of sugar to 3 parts of writing ink. Printer's rolls and hektograph pads are made from glue combined with sugar or molasses. The silvering of glass mirrors is another important industry in Europe. Sugar, after inversion with acids, is here used to reduce an ammoniacal solution of silver nitrate which deposits a coating of silver on the glass immersed in the solution.

The hardening and strengthening action of sugar in mortar was known to the ancients in the far east and it is said that the Romans also made use of saccharine solutions for this purpose although sugar, known as "Indian Salt," was rarely seen in the Empire. Some of this ancient masonry containing sugar still stands in good condition.

In recent times, the Museum of Natural History in Berlin has been rebuilt with mortar consisting of 1 part of lime, 1 part of sand and 2 parts of sugar. Sugar is also used for hardening plaster moulds.

In many chemical operations, sugar is used as a source of carbon of high purity such as in the manufacture of pure carbon monoxide or sulphurous acid. As to future application it is possible that sugar may become of great industrial importance through its nitro compounds. Nitro-saccharose (sucrose octonitrate) is a product analagous to gun-cotton which, it is said, can replace the latter in its numerous applications in explosives, collodion, celluloid and the like. Similarly, it is claimed, sucrose acetate can take the place of the corresponding cellulose compound in viscose and artificial silk.

Certain compounds of sugar and benzoic acid also show promise in this direction.

This list of industrial applications of sugar is by no means exhaustive but perhaps suffices to illustrate the great diversity of manufactures in which this product appears quite apart from food economy.

SAFETY OF STEEL RAILS

In the testimony which President Farrell of the United States Steel Corporation gave before the Stanley Committee, he declared that the steel rails now produced are unsafe, stating that the high carbon steel now required is a source of danger, and that a soft metal would be far better, as far as the safety of the track is concerned. The liability to breakage is much greater than in the old-time soft steel rail, and the unavoidable contingencies of manufacture, such as seams, pipes and segregations, are more likely to be present.

This statement is in line with the growing opinion among most metallurgists. High carbon steel has been employed to obtain the stiffness necessary for an easy-riding roadway, but recent accidents have set experts wondering whether the loading of the rails has not gone beyond the maximum necessary for safety.

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OIL BLOCKS FOR MARINE FUEL

During recent years the attention of marine engineers has been devoted to the methods of using oil for the purpose of making steam in the boilers of ships, but although many forms of spray fuel burners have been devised, a very serious obstacle appeared in the changing of existing apparatus which would be necessitated by the use of the new fuel. Devices for loading the combustible would have to be changed, immense tanks would be needed for the oil, and the action of the oil in the tanks would be felt when the ship was rolling.

At a recent meeting of shipowners in London there was a full discussion of the matter and it was decided to advance the idea of solidified petroleum brickets. These brickets are very simply produced, being made of boiled crude oil to which is added stearic acid with an alcoholic solution of caustic soda. The cooled solid is a transparent mass having sufficient cohesion to be shaped. The brickets are easy to handle, have a slow and regular combustion, are not affected by the weather, and pound for pound, are two and a half times as effective as coal. They would save a large amount of space on shipboard, it being estimated that on a single trip of a Cunard liner from England to New York and return, the lowest figure of saving would be $60,000. The solid oil could be handled by the present loading fuel apparatus with little modification and storage facilities would hardly have to be changed. One of the important features of course is that the range of the vessel would be very much increased, an important point in war vessels.

ACTION OF SHRIMP ON TIN

The popular idea that only acid substances attack tin is wrong, says the *Scientific American*. Fish, asparagus, beans, pumpkin and spinach are not acid and yet their corrosion of tin is quite marked. This is probably due to amino compounds, substances related to ammonia. In the case of shrimp, the cans are often eaten through in a comparatively short time. So alkaline is the methylamine contained in the shrimp that workmen in the canneries find the skin peeling off their hands and their shoes eaten through. Shrewd observation by some canners led to the discovery that if the shrimp were iced for a day before canning the corrosive action of the juices was greatly diminished. This is now the universal practice. In addition the cans are lined with paper to prevent contact of shrimp and tin.

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THE IMPORTANCE OF NEGATIVE EUGENICS

HOW FAR MAY WE GO TO ERADICATE A PERSISTING TAINT WHICH IS RESPONSIBLE FOR BETWEEN TWO AND THREE PER CENT. OF THE OBVIOUSLY UNFIT.

BY WOODS HUTCHINSON

EUGENICS is the art of the intelligent selection of our own parents. Unfortunately, most of us were not consulted as we should like to have been, about that matter, but we can see that the next generation is to some degree consulted. The problem of the method of preventing some of the unfortunate results which we see about us on every hand is one of the most vital and important things that confront us, not merely as sanitarians, but as humanitarians and as lovers of our kind. In the beginning, as most of you are aware, the direction taken by the eugenic movement, started under the brilliant and able leadership of Sir Francis Galton, was toward careful promoting of the mating and reproduction of the especially and peculiarly fit. That raised the question as to who should decide who were the specially and peculiarly fit, who were to be endowed and bowed down to by the rest of the community, and, not unnaturally, those, who first began this movement, selected their own class as the class that ought to be so endowed. And from that point of view, eugenics began. There were to be special classes of individuals and careful study was made, statistical study, if you please, showing how much more valuable, how many times more valuable to the community the child of a professional man or a well-to-do merchant was than the child of a day laborer, and how much more valuable still was the child of one of our great families. That was the principle on which the plan of campaign was to be conducted, but as soon as that began to be worked upon, we were faced with many objections.

In the first place, we found that while we would like very much to promote the reproduction of the fit, none of us knew enough to determine accurately who were the fit and who would reproduce the highest type of the future individual. We don't know what the future man is going to be like. Mr. Bernard Shaw thinks he knows, but he is the only man who has even ventured to express an opinion in that regard. We don't know what to breed to. We have to keep the human animal plastic and open to response and above all things, avoiding all kinds of specialization of fixing of type. We are middle-of-the-road animals and have won our victory by being able to beat every other animal at its own game and in its own element, and only by keeping that up will we succeed in improving the future of the race.

In the second place, we found that all our comparisons with the lower animals were vitiated by a serious fallacy, that while we could produce certain changes in the lower animals at will, by selection, those changes were not for their benefit; they did not improve them from their point of view or enable them to compete better in the struggle for existence, but were made for our benefit; and the proper selection of the human breed will not stand comparison for a moment with the

attempt at so-called improvement and development of high grade stock in other types of animals.

The third thing we discovered was that the genius was a remarkably rare and fortunate accident and that the very fact of a genius having appeared in a family was pretty good evidence that there wouldn't be any more geniuses in that family for at least twenty or thirty generations; and finally we found that when the community had acted upon the principle of endowing the successful man with titles and official position, or landed estates in the hope that he would produce a class of people of greater value to the community, what really happened was that the brilliant and able man married a commonplace wife and produced commonplace children. So that we locked up, for the benefit of not more than 3 to 5 per cent. of the community, something like 30 or 40 per cent. of the resources of the right of primogeniture and by the unrestricted right of inheritance of private property, which is one of the things that will have to go down in the future. We had succeeded in starving and crushing out and killing at least five to ten geniuses in the great 70 per cent. of the people for every one we bred to order in the upper 5 per cent. of the community.

So the next line eugenics decided to take up was the negative side, preventing the reproduction of the obviously and clearly unfit. Here we had the advantage of having a criterion about which there could be no two opinions. It was perfectly possible to establish a criterion of normality and everyone falling below it was to be regarded as an unfit and undesirable type to reproduce, and it was not very long before we began to make the exceedingly interesting and most encouraging discovery that the larger part of those qualities which rendered the individual unfit for competition were things handed down to him from his ancestors and which would be handed down by him to his descendants. I need not detain you with the statement of the actual results of these investigations. They are familiar to practically all of you. But it was found that about from 2 per cent. to 3 per cent. of the community were congenitally defective and from that 2 per cent. to 3 per cent. sprang the enormous mass of our feeble-minded, of our epileptics, a large share of our insane, a large share of our prostitutes, a majority of our criminals and the vast mass of our paupers and tramps; that we had gathered together, as it were, in one stream and one line, a tremendous number of the undesirable and unfit element of society.

Plans were proposed at once for the limitation and the cutting short of the further perpetuation of this type of individual and this contamination of the race stream, this pollution of the blood of the community. The most careful investigations have shown that never, from a feeble-minded father and mother, has been born a normal child—no instance has been brought forward where that miracle has occurred, and according to the percentage of defects, obvious or concealed, which exists in the parents, so will be the percentage of defects in the offspring. These conditions emphatically breed true and if we can manage to break this stream in one way or another, we shall succeed in stopping an immense number of these defectives and misfits of our human species. The method suggested for doing this is the simple one of extending the care of the schools so that intelligent experts in mental development, intelligent physician, and a born teacher, shall examine every child in the community, certainly as early as three years and preferably earlier, and watch for the development of the little peculiarities, showing these hereditary defects. When these defects are discovered, those children should be taken and placed in a special environment out in the country under the most favorable and happiest circumstances and trained and developed to the highest pitch they can possibly be, but prevented from reproducing their kind by permanent segregation. When this has once been done, it would only be a few decades before we should see a rapid falling off in the percentage of pauperism,

crime, insanity, epilepsy and feeble-mindedness.

The question is now, are we producing this defectiveness, this feeble-mindedness, these hydra-headed forms of defectiveness? Is it a breakdown under the strain and stress of civilization, or is it merely the persistence from an almost indefinite period in the past, or radically defective strains?

In other words, are we manufacturing our defectives or are we merely perpetuating the defectiveness which has been inherited from past generations? On that subject a great deal of admirable work has been done, resulting in the conclusion that we are not manufacturing defectives, that the strains of civilization are not producing mental defects which manifest themselves in the form of feeble-mindedness, epilepsy, insanity and crime; that these are not increasing under civilization, but that we are simply perpetuating, from some far period in the history of the race, a strain of mental and physical defects. It is merely an arrest of development, the lowest type of the feeble-minded is the individual whose development is arrested at about the age of the child of two; the next lowest is one whose mental development is arrested at about the age of a child of six, and the next lowest is one whose development is arrested at about the age of a child of nine, and so on, until, if we go very much further, we might begin to make invidious personal comparisons which would not be altogether—well, you don't want to carry anything too far, as Doctor Sedgwick said.

The situation appears to be that there are two great reservoirs of this mental defectiveness, one of them being, not the city slum, for that has a lower percentage of feeble-mindedness, epilepsy and insanity than the poorer and remoter class of open districts which are the real rearing places for our defectives and feeble-minded—but the little colonies which dot our country all over from the fisher villages of Nova Scotia and the coves of the Allegheny Mountains, to the pine barrens of the Southern States and the swamping river-bottoms of the West. Probably everyone of you has known of some such community of chicken thieves and drunkards and paupers and feudists and smoke-house robbers who live off by themselves and interbreed, protected from elimination by the very low grade of their surroundings and the small amount of strain which is brought to bear upon them. They live like animals because they have an animal mentality and are placed under animal surroundings.

The other reservoir for that defective strain is the group of privileged doodle-wits at the other end of the social scale, whose eccentricities have been carefully preserved and protected from the fool-killer on royal thrones and in millionaires' families, in Four Hundreds and upper Ten Thousands and groups of that kind, safe from the competition and pressure which would otherwise have wiped them out of existence. In the intermediate and lower ranks of life there are not so many of these defectives, but there are historical instances that recall themselves, of a magnificent succession of degenerates. Indeed if sterilization of defectives had been insisted upon in the past at least three royal houses in Europe would have been put out of business generations ago. I do not mean to say that there is naturally any greater proportion of defectiveness among them than among other elements of society, but they are maintained by their family and rank and kept in a position where that defective strain can spread and trickle downward; it is even considered an honor by the remainder of the community to have it mixed with their blood.

The question to what extent two great sources of deterioration produce this defectiveness is, I think, worthy of a moment's attention. They are the two great curses of civilization, alcohol and syphilis. Is it true that we are filling our jails and asylums and homes for dependents, because of the use of alcohol and the prevalence of syphilis, or is the relation the reverse action? That is, that alcohol is a germ poison, picking out the weak individuals and detecting the weak spots in the community, instead of actually causing them? The general

trend, I think, of investigation, tends in favor of the latter view. We can hardly imagine it to be otherwise when we remember the way our ancestors used to boast of the number of bottles of port they could carry. We would all have been dead long ago if mere alcohol had been sufficient to produce defectiveness. I don't know whether any of you remember the standards that obtained when the first temperance society in New England less than a century ago was formed. Its pledge ran as follows: "We, the undersigned, believing in the evil effect of strong drink, do hereby pledge ourselves on our sacred honor that we will not get drunk more than four times a year, Muster Day, Fourth of July, Thanksgiving and Christmas." That was the beginning of the first temperance society, and a community which could stand such potations and saturations as that, is not going to be seriously damaged by the drinking that is going on at the present date. I believe that these two conditions, instead of producing defectiveness, merely pick it out and we should regard the drunkard and the individual who goes insane from syphilis as emphatically not to be trusted to reproduce the race. That our laws as regards divorcing such individuals should be made practically self-acting instead of encouraging good women to marry men of this description in the hope of reforming them by their Christian principles and their good example; that, I think, is distinctly immoral, I care not who has upheld such a position.

The last bearing of this question that I should like to call to your attention is as to the amount of this type of defectiveness. Of course we can pile up perfectly enormous and appalling figures running up into the hundreds of thousands, of the different types of defectives—feeblemindedness, criminality, insanity, prostitution, etc., but, taken altogether, they do not come to more than 4 per cent. or 5 per cent. of the total community; 95 per cent. of the community are born normal and sound and the vast majority of us, no matter what strains we should be subjected to, are hopelessly and monotonously sane, not even cranky enough to be interesting. The general average of the race is high and good, and the real field of eugenics, in my judgment, is the recognition of this fact, first of all. By all means, weed out, by appropriate and kindly segregation, those unfortunates who have been born accursed and prevent them from passing on that tainted plasm to the next generation, and we should soon see a marked improvement in affairs. The next thing is to alter our attitude to the great mass of the people—and that has been the most serious and dangerous result of this strain of defective plasm in the race. We have actually taken, in our inspired intelligence, that 2 per cent. or 3 per cent. of defectives as the creatures which all men would become if they were not held down by the strong hand of the law or upheld by the support of religion. We have pictured 2 per cent. or 3 per cent. of defectives as the basal type of the entire community and have allowed that to color our laws, our prison regulations and our methods of what we are pleased to term justice, until we have produced a code which, for savagery, stupidity and ineffectiveness to 97 per cent. of the community is never needed for a moment, except by the 3 per cent. of unfortunates at the lower end of the scale. We should recognize that the tendency of 95 per cent. of humanity is upward and forward and that the vast majority of men would be law-abiding if there were no laws. That the place where our geniuses and our great men and desirable individuals are bred and born is in that 75 per cent. to 85 per cent. of the race, which is the backbone and seed bed of every people, and that the main thing needed in eugenics is to preserve and conserve the virtues of the heredity of 90 per cent. of us. I believe that we shall come to feel more and more that the man who is to be chiefly regarded is the average man and not the exceptional man, neither the exceptionally and unnecessarily good nor the exceptionally bad. That the people to whom we should direct our attention and for whose welfare we should work, are, in Lincoln's phrase, "the great, plain people whom God Almighty must have loved, because he made so many of them."

REVIVING A DYING INDUSTRY

WHAT A TECHNOLOGY GRADUATE IS DOING IN SCIENTIFIC AND SYSTEMATIC CULTIVATION OF CLAMS. RECLAIMING FLATS EXHAUSTED BY OLDER PRACTICES

BY JOHN RITCHIE, JR.

Revival of neglected and wasted sea-farming opportunities is a matter that is much discussed today in Massachusetts and is attracting some capital. The whole subject is timely on account of its direct relationships to conservation and is of especial interest to Science Conspectus and its readers in that the initial scientifically directed effort lies to the credit of a past student of the Institute of Technology. The systematic first work towards reclaiming the neglected sand-clam flats has been deliberately undertaken by Andrew Kerr, '06, a student in the courses in biology. Sea farming has been much developed by the older nations especially in the Orient, although the efforts here have been devoted to utilizing sources of food not yet available to the Occident, being driven to it by necessity as these people have been to their intensive cultivation of the land.

There are some of the shell-fish that have always been taken for food and a few of these have been developed for the reason that there is known to be large profit in the systematic cultivation of them. The oyster has been a staple for decades and the minutiæ of its care have been reduced to a science. Likewise the value of the industry has led to laws which have made it practicable to develop it. Another shore crop has come more recently into vogue, the little neck clam, which is grown—though without much science—for the great returns that it will yield. The third of the shell-fish group in Massachusetts waters is the scallop, much esteemed, but subject to the traditional belief, fortunately lately dispelled that they may be here today and tomorrow pull up stakes and go to some unknown locality. These three fisheries are more or less in the public eye, but no one hears much about cultivating the sand clam, Mya arenaria, the favorite for bakes and chowders, although if properly carried on the industry may be quite as profitable as either of the others.

So far as the oyster is concerned, since the annual consumption in this country is about fifty cents per head of population, the importance of the industry has led to laws which, like the laws pertaining to agriculture, protect the oyster grower in harvesting his crop. The quahaug is not protected, but the places of its growth are similar to those in which the oyster develops so that cultivation on oyster beds affords a measure of protection. The scallop is to a very limited degree migratory but not regularly or in schools or to a distance. The laws have had reference largely to "seed" scallops, quantity to take and close season, with some local town regulations. And as for the sand clam, it is practically without protection today, although there are plenty of places suited to its cultivation. The general attitude of the laws, the reckless wastefulness of the clam diggers and the sinfulness of the community in polluting good beds with sewage are rapidly driving the clam out of existence as a Massachusetts food supply for Massachusetts people.

This situation is not a new one. For a decade and more the Fish and Game Commission of this State has been calling attention to the necessity for a different policy. Notice has been given to prominent cities that are befouling neighboring flats that might yield their fishermen good profit, and an educational campaign in literature and addresses has not been wanting, but it has remained for Mr.

Kerr and his associates to make the definite proof of the pudding, to undertake in a commercial way the scientific and systematic culture of the clam and the reports from the clam farm at Plymouth are highly encouraging.

To outline the legal situation in Massachusetts with reference to the clam and other edge-of-the-water shell-fish, it is merely necessary to say that in the patriarchal spirit of its early days the Colonial Government of the province gave to every one of its citizens the right to take a daily ration of clams from the shore wherever they might be found. The principle is a familiar one in everyday practice for any one may fish from the rocks that jut into tide water, or hunt along the tidal shore and shoot at birds unless there are definite special restrictions.

The law makers have realized that indiscriminate hunting is killing all the birds and to some extent they are now protected, but the limitations to the taking of shore products are little greater than in Colonial days. The injustice of this freedom makes itself felt more and more as the population increases. One may plant potatoes in his field and be assured that he has some legal right to his crop, for custom and the laws support him here, but one's crop of clams on the beach is at the mercy of the first citizen who thinks he would like a clam supper. Even the experimental grounds occupied by the State at Essex were not free from invasion. Here, since the sower has no certainty of reaping, there has been no care about replenishing the stock, no cultivation; but on the contrary, continual waste. No one is careful of what does not belong to him, and citizens in general are particularly wasteful of what belongs to the municipality or state, so the diggers of the past have had no thought for the morrow, but in taking for their immediate needs have exposed growing and seed clams to conditions that have tended to destroy them. The clam candle has been recklessly burned at both ends, the older clams have been eaten and the young ones left to die. Little wonder is it, then, that Duxbury and Plymouth, famous in older days are now practically out of the ranks of the producers, that Essex and Newburyport have lost most of their crop, that in Fall River and Buzzards Bay the flats have become exhausted, in these latter places notably by the destruction of the seed clams, while the great Boston harbor has been proscribed on account of pollution by sewage. Other places are in the same predicament. Portions of New Bedford Harbor are condemned, and suspicion seems now headed towards certain important clam flats of Newburyport. One can hardly credit that an important industry in a desirable food product can have been so neglected and is almost at the point of passing into the hands of out-of-the-state communities. The more unfortunate would this finality be when it is remembered that there are at least ten thousand acres—nearly sixteen square miles—of clam flats that might be productive lying along the shore line of Massachusetts.

There is, however, a little relief, which shifts the responsibility for present conditions although it has not as yet changed them. There is an option that the town may ask of the Legislature, the administration itself of the shore rights within its borders. Three groups of towns, numbering in all five places, have asked for and received such authority, Plymouth, Kingston and Duxbury, abutting on the shore of the same harbor, Essex and Barnstable. Plymouth was the first to apply, the act dating back to 1870, and Essex and Barnstable are recent additions to the group. In Plymouth it was purely a movement of conservation. There were important fishing interests demanding bait and the clams were being exhausted. It was proposed, therefore, to begin the cultivation of the clams, to re-seed the flats and to assure to the fishermen a perpetual supply of bait. The fishing industry, however, established itself elsewhere and the policy of assigning flats to individuals was not taken up till the matter was brought to the attention of the authorities by Mr. Kerr, who now holds under this law.

The advantages of a shore industry,

Plate I. An undesirable flat. Seed clams catch here but will not grow. The seed clams were taken out of the space beneath them.

Plate II. Clam flat at low tide showing furrows.

Plate III. Three months' growth, the seed clams being within the dark ring.

Plate IV. Eight months' growth. All outside the dark lines has been added during that period.

like the cultivation of clams, are not to be overlooked. Nature is working in the environment that she has herself established. The plants and animals live under conditions where the balance has been arrived at between creatures and their enemies. There is here no risk of drouth or flood, the serious ones on land, but there are the dangers of storms and destructive animals. Oyster beds are occasionally destroyed by storm-washed material, and the same is true of exposed flats, but in the former case the injury is infrequent, while clam flats, in positions where such damage is probable, have been destroyed long ago. As to destructive animals, the great spherical Natica that is the chief enemy of clams, is itself valuable for bait, and is taken for this and thus kept under control.

The fisherman who has a water farm may look for his crop year after year with regularity. It is not an itinerant shoal of fishes, here today and tomorrow off on a globe-finning expedition, as the tile fishes are wont to do. There is in the shell-fish farm a crop more certain than any thing on land, save the weeds, and these are helped, just as the mollusks are, by environment. The man who raises wheat or corn may realize, it is said, from twenty-five to thirty dollars an acre in New England, or he may cut a ton of hay. Alfalfa, the farmers' easy way to wealth, may yield one hundred dollars an acre, and cranberries, when all the conditions are favorable, may touch two hundred and fifty dollars, and this is about the yield that the clam farm will assure. There are intensive cultivations like truck gardening that will go much higher, and there are, likewise, sea crops like the oyster and quahaug that may match them, but it is the staples that should be compared, when cultivated and harvested in easy ways by ordinary unskilled hands.

This setting forth of these premises leads to the main point of the argument, that here is an industry that is now taken out of the domain of guesswork or rule of thumb and placed on sound reality, for Mr. Kerr has secured his sea farms, sowed his seed and gathered his harvest. It was a deliberate line of action that he took to the present success. He realized the clam situation a dozen years ago through a boyish experience in Maine; the study of biology at Technology helped strengthen his plan and quietly he has been developing his work. It includes taking advantage of natural facilities when Nature is pointed the right way and the correction of errors when mistakes are made from the human point of view.

The conditions in Plymouth harbor present a large area of flats available for clam culture, which have practically been exhausted, and large reaches of gravelly bottom. The White Flat lies over towards Captain's Hill in Duxbury, about half a square mile in extent, and there is near by Ichabod's Flat of 270 acres. These are in the Kerr Sea Farm.

The clam is at first a free swimmer and it is the ordinary occurrence for it to be swept in quantities into unfavorable places. Here the little bivalves develop for a while, but have not the conditions to maintain their growth. They are crowded in what space is available, and presently are arrested in growth or die.

Such an uninhabitable stretch is shown in Plate I, the mass of clams having been taken from the ground directly beneath them. This will serve to show how thickly Nature may seed them in unfavorable places, where they cannot mature.

This temporary storehouse of gravel has been the source from which clams have been taken to stock the White and Ichabod Flats. It is a good reservoir and has yielded up to three or four thousand seed clams to the cubic foot, practically every one of them doomed to death if not removed from congestion and unsuitable environment.

The sea farms, as one may see from Plates II and V, are not so different from those on land. Furrows are dug and the seed clams regularly planted. They establish themselves in their new homes at once and testify to their proverbial happiness and satisfaction by taking on a rapid growth. Plates III and IV testify to this without the need of explanation, save that the shell included within the dark line marks the size of the clam when transplanted; the rest is growth on the

Plate V. How the clams are sowed in the furrows.

flat. The clams in Plate III were three months in their new home on White Flat and those in Plate IV show the comparatively enormous growth under good conditions in eight months. The latter are marketable clams.

There are carefully kept figures that tell the story of the growth, and an increase of twenty-fold in the weight of the meat after six months of cultivation is the average. Clams that have lived in the sand of the flat for two summers have gained about seventy-five times in the weight of the meat. When, however, they get to be very large, say from four to five inches in length, the growth is slow. Further than this there is a marked difference in the shell of the clam that develops in rocky reaches. The illustrations hint at this, but give little definite idea of the nature of the difference. Naturalists will know at once that the shell that is in rocky sea-bottom must itself be heavy in structure to withstand the vicissitudes of the gravelly surroundings, especially if there is motion to the water. The difference is really considerable, the sand clam from the flats having one-fifth of its weight in the shell and the gravel clam having one-third, so that two gravel clams may be considered as putting as much food and energy into the building of their shells as three of the clams from White Flat. With a million clams to the acre the ratio of shell to meat becomes of economic importance, and six hundred thousand to a million is the capacity of such a sea farm as White Flat, while in shipment, it is desirable to pay express on as little waste as possible.

The mysterious isothermal layer of the air, in which temperature ceases to fall with rise in altitude, has been chiefly investigated in Europe, but within the last year many balloon soundings have been made in Canada. These have shown the layer at an average height of 8.1 miles. Two Germans, Drs. Rampp and Wagner, have now begun a year's scientific researches in Spitzbergen, and are studying this strange air phenomenon in the cold of the polar night.

THE PYRAMIDS AS AN ASTRONOMICAL MONUMENT

PRIMARILY BUILT TO CAST A KING'S HOROSCOPE THE PYRAMID OF GIZEH WAS, APPARENTLY, A GREAT OBSERVATORY, THE GRANDEST EVER ERECTED BY MAN.

BY PERCIVAL LOWELL

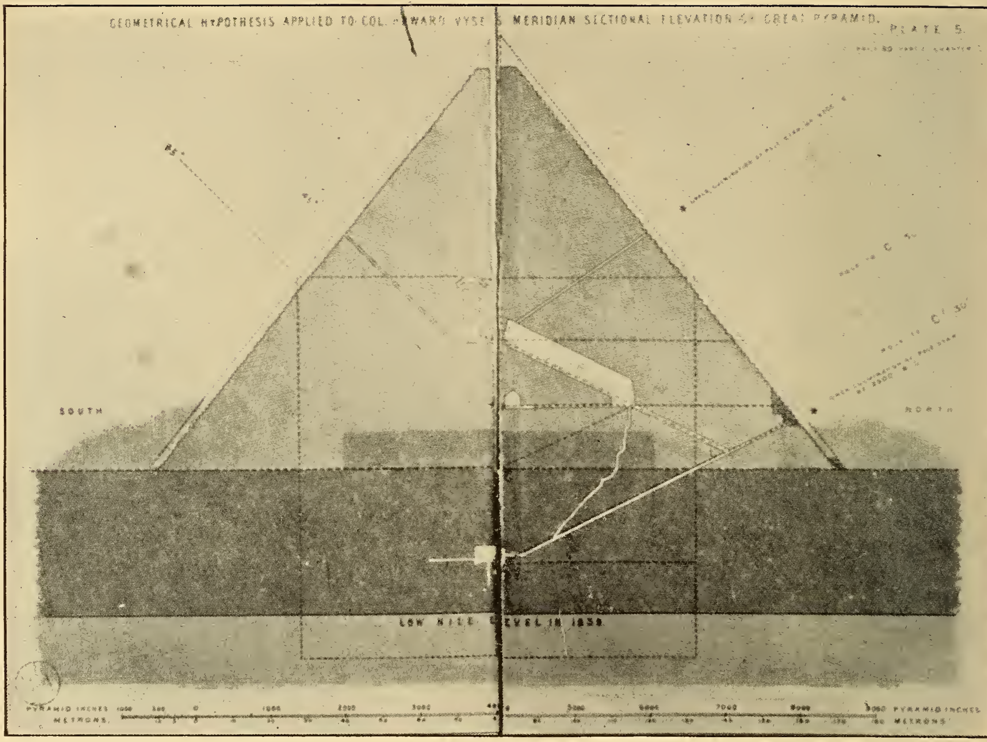
THE Great Pyramid of Gizeh holds in itself, perhaps, the most romantic and certainly the most majestic period of the past. The story which it conjures up, as you will shortly see, will, I trust, bring vividly before you a scene, the grandeur of which—although it is science pure and simple—is unsurpassed.

Most people date their acquaintance with the Great Pyramid from their first school geography in which a solitary camel and unlimited sand typify the desert. Rising from this picture to a perspective view in ancient history they next acquire of it, to judge from the text-books, much miscellaneous misinformation. Thus one of the most popular of these purveyors to the young in secondary schools informs the innocent that: "*The* Egyptian art was architecture, especially of the temple and the tomb" and that "of the last the Pyramids are the great example" though "only exaggerated reproductions in stone of savage grave mounds like those of our early North American Indians." This startling nugget of knowledge is true only in the *grammatico-algebraic* sense that two negatives make an affirmative. For they are not examples of art on the one hand, nor are they Egyptian on the other. They are, in fact, the embodiment of Chaldean science. Now science is the acquisition of truth; art the perpetuation of beauty. The two are as distinct as are generally the good and the good looking.

Youth is next informed that the Nile has been credited with influencing their form the better to withstand its annual inundation. Considering that the oldest of them, the pyramids of Gizeh dating from the fourth dynasty, are carefully placed on the plateau well above any possible flood, this illuminating surmise may perhaps not hold water. But that serves to introduce us to the first thing we notice about the Pyramids: the shelf on which they stand and the latitude at which this shelf lies.

To be told that five thousand years ago the Southern Cross could have been seen by one standing where London stands today would certainly cause most people surprise. Nevertheless such was the fact. That celestial asterism to which persons who have not seen it look forward as to one of the revelations incident to voyages into the tropics and then, on beholding it, feel egregiously duped, needed then no far travel to disclose. The sad disillusioning caused by its rising could have been enjoyed without leaving home. For 3000 B.C. its center-void apology for the real thing might have been observed above the outline of the South Downs at midnight at the proper season of the year by a stargazer at the then mute and inglorious Greenwich.

If amazed at the apparition our tourist thus transported back in time turned to get his bearings from the north, not less astonished would he be to discover his old friend, the pole star, unaccountably gone. Even the learned might experience a shock. Certainly to those who drink in their star knowledge through the medium of the Dipper would it prove disconcerting to find Polaris adrift in the sky. Its fixity fled, our cynosure would indeed be difficult to detect. Just as mediocrity exalted by office sinks into plucked insignificance once its insignia



Geometrical Hypothesis applied to Colonel Howard Vyse's Meridian Sectional Elevation of the Great Pyramid

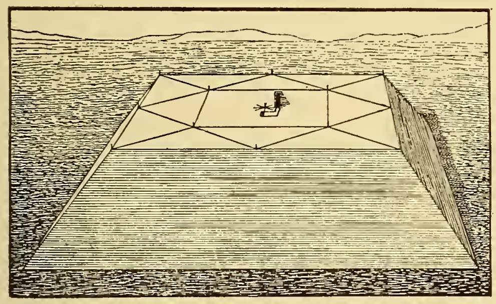
are removed. Nor would he find the solace of familiarity anywhere else. For such upsettings of fundamental fact would confront him everywhere. The whole firmament would appear to be turned topsy turvy could we suddenly be canopied by the heavens of those departed days. All the constellations would seem askew even if he succeeded in making them out. Nothing new under the sun! perhaps; but a very different state of things under the midnight stars.

Not only was α Draconis once the pole star, but it was actually so seen of men who have left us record of the fact. And this, too, without the slightest idea that they were dating history, and in the most dramatic manner possible. Not by carved or written inscription, not by oral tradition handed down by word of mouth, was this accomplished, but in a way at once more silent yet more sure—mutely embodied in the very core and being of a building the grandest ever erected by man. The Great Pyramid, the pyramid of Cheops, tells us this in stones that bear no character at all and only astronomy can read.

Herodotus, the "Father of History"—known also as the father of lies in what may be called the Ananias Club sense, for we are now learning that what he narrated, though seemingly unbelievable, usually turns out to be true—informs us that when he was in Egypt he was told by the priests that a long time before certain peoples had come down from the north, possessed themselves of the Egyptian power and so far affected the mind of the then King Cheops or Suphis that he forsook the Egyptian religion, caused all the temples to be closed and set to work under the stranger's direction to build a huge pyramid of stone.

The same veracious if also voracious historian goes on to say "that 100,000 men were employed for twenty years in building it; that Cheops was succeeded

by his brother, Chephren, who followed his pyramidal example; and that by the space of one hundred and six years all the temples of the kingdom were closed." In consequence the pious Egyptians deprived of their natural religious vents "detested the memory of these kings"; as they may well have done for other than religious motives, seeing that they were employed at forced labor on such a scale for such a length of time.



The Great Pyramid Observatory

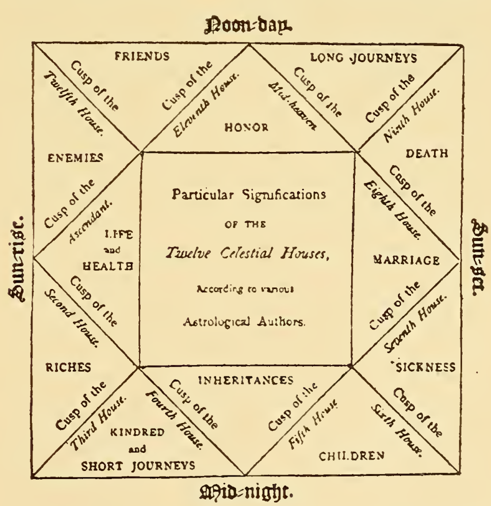
Manetho, who confirms the royal apostasy mentioned by Herodotus, gives us to suppose that we have here an invasion of the shepherd kings about the time of Abraham. Their force seems to have been intellectual, as they overturned the whole Egyptian system of things, he says, without a battle. So that they were probably Chaldeans, and the pyramids which they caused the king and his successors to construct were not Egyptian monuments at all, but embodiments of a foreign cult peculiarly distasteful to the followers of Isis and Osiris. Indeed, as we shall presently see, they were neither Egyptian nor monuments.

What they were not is plain; what they were has best been deciphered by Proctor, who has shown well nigh conclusively that their purpose was astrologic. That they were astronomic constructions they themselves reveal, and the only rational explanation of the power the strangers gained over the mind of the king lies in the astrologic art the Chaldeans are known to have possessed, and which is also known to have been eagerly sought after by all the peoples of the east.

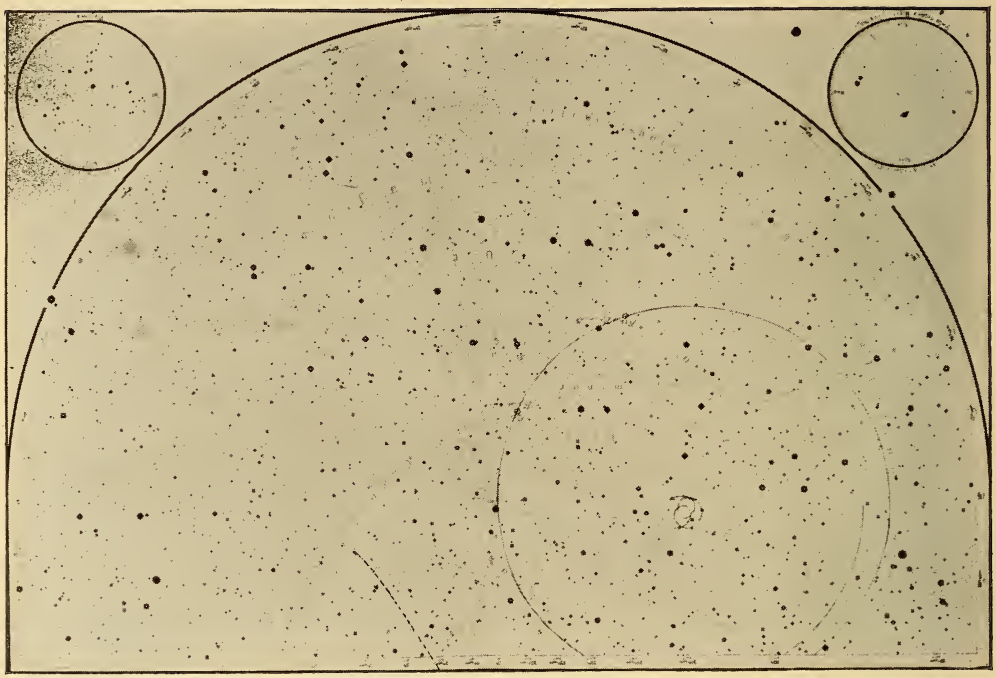
Both without and within they testify to a very heavenly regard on the part of their builders. In the first place their situation is expressive. They stand within a mile of the thirtieth parallel of latitude and undoubtedly were only prevented from standing nearer that astronomic line by the fact that the plateau shelf on which they were erected here falls abruptly to the plain. At this point on the earth the north pole is 30° high, and thirty degrees has this commendation to geometers, which the pyramid builders emphatically were, that a perpendicular from it to the line of sight is at that elevation exactly half as long as the line of sight itself.

In the next place the base of the building is four-square, its sides being oriented to the compass points with surprising accuracy. Just as Christian churches face the east, that is Jerusalem, and Mohammedan ones Mecca, so the pyramids faced the north. Here then we have surmise of both religion and astronomy, to wit astrology, embodied in the mere outward aspect of these constructions.

This is, however, as nothing to what the interior reveals. Upon the north face



of the Great Pyramid a passage opens, descending for 350 feet through tiers of stone at first, then through the solid rock. This passage points to the north within 4′ or 5′ in azimuth, is perfectly

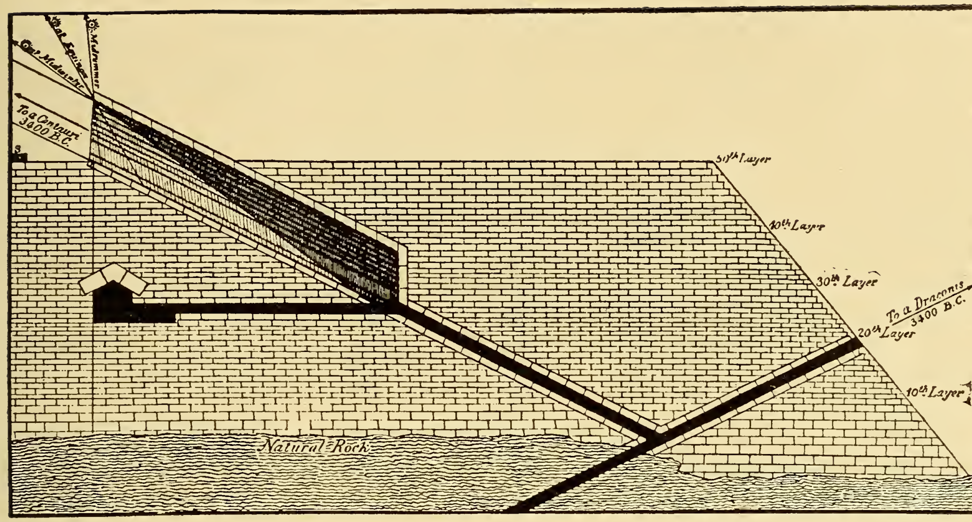


The Great Precessional Path, and the wanderings of the Ecliptic Pole

straight and is inclined to the horizontal at an angle of 26° 27′. The long straight hole suggests that it was used for looking at a star, for down it a bright star might even be seen by day. Its direction, moreover, hints that the pole star was the one in question. Now the latitude of the pyramid is 29° 58′ 51″. The subterranean tube, therefore, does not look directly at the pole; but when we take refraction into account we find that it would look exactly at a star distant 3° 34′ from the pole when that star was at its lower culmination, that is, passing the meridian directly south of the pole.

Now if in latitude 30°, a man wished to observe the north or south passage of a circumpolar star, in order, for example, to ascertain true north, the best means of doing so would be to dig a subterranean passage-way pointing approximately northward and then mark through it when the star ceased to rise or sink; and since either culmination would suit him he would naturally choose that one in which the slant of his tunnel would be the least, both because he could dig it easier and because he could descend it best. An incline of twenty-six degrees is distinctly preferable to one of thirty-four. Now 645 years before or after the date when α Draconis was approximately upon the pole, it was 3° 34′ distant from it; that is, in B. C. 3430 or B. C. 2140. The passage, then, chronicles the time when the pyramid was built—with a seeming choice of alternatives. But the nearer of these is negatived by what we know of Egyptian history and we are thus left with the other, that of B. C. 3430, as the date of the pyramid's construction. The pyramid thus dates itself astronomically, which is the first remarkable thing about it.

It is to be noticed that astronomy here furnishes Egyptology with a fixed epoch from which to go forward or back. We are not here dealing with conjectures as to when a certain king or dynasty can be made to fit into a general chronologic



Vertical Section of the Great Pyramid showing the Ascending and Descending Passages, Grand Gallery and Queen's Chamber

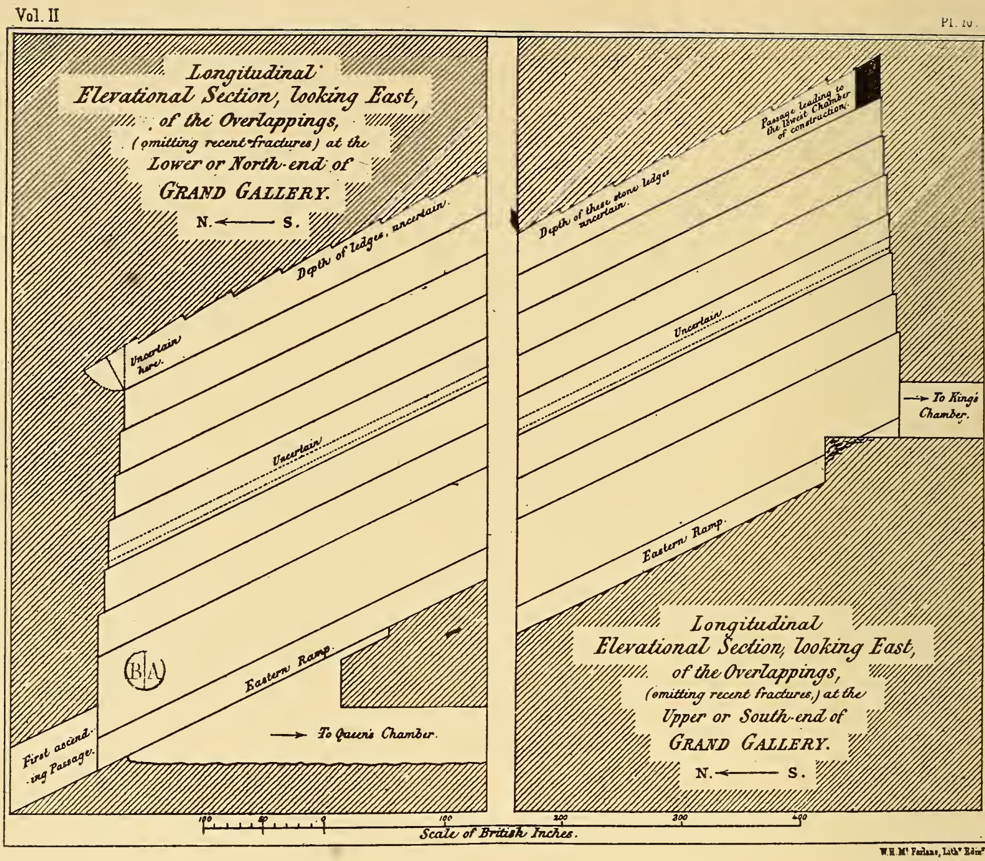
scheme by the relics it has left us of itself. Calculations from known astronomic data can tell to an exactness gauged only by the size of the opening of the passage as seen from below precisely when the pyramid was built with only the choice above described. To deny which would but argue a lack of appreciation of physical science. For that such a pointing can be but the sport of chance, the whole structure of the pyramid emphatically denies.

The Great Pyramid was in fact a great observatory; the most superb one ever erected. The building is the most mammoth in the world, and it had for telescopes something whose size has not yet been exceeded. This something, which did those old astronomers for instrument was the Grand Gallery. As its name implies this was a stone gallery of imposing proportions set on an incline of 26° 17′ 37″ in the very heart of the structure and pointing south. It is approached by the descending passage which looked at the pole star and thence by an ascending one at about the same angle which opens into it. It is one hundred and fifty-seven feet long, twenty-eight feet high and about eight feet wide. Along the center of its floor a smooth stone flagging ascends, flanked on either side by raised curbs or ramps half as wide each as the central paved pit. These curbs are not continuous but are cut at approximately equal intervals of about five and a half feet by notches with vertical edges. There is no doubt that these were for the insertion of benches, as the notches tally on opposite sides. At about sixteen feet from the bottom the central incline stops in a vertical wall which descends to a horizontal pavement, giving entrance to the corridor which runs to the Queen's apartment.

The roof of the gallery is everywhere smaller than the floor, so that it overhangs the bottom about one foot eight inches on three sides, 39.5 inches at its southern top. The stones on the sides are carefully set in tiers, the sides themselves being oriented to the compass points. Its exact dimensions which we shall find telltale are:

	Inches
Inclined length of floor	1,815.6
Same produced to south walk	1,883.0
Height	339.0

It is now of course walled in by stone on every side, but in the day of its use it undoubtedly stood open at the top, the horizontal passage in which it now ends at the summit having been the beginning of the platform of the whole pyramid, at that height. No records tell us this; our



Longitudinal Sections of the Grand Gallery

information comes from the gallery itself. Now if we calculate the angle from the vertical which the end of the cornice makes with the upper end of the floor we shall find it 6° (6° 20′). Remember that the gallery faces due south, so far as the builders could place it, that the latitude was 30° (29° 58′ 51″) and that the obliquity of the ecliptic was then 24° (24° 4′). Now subtract the second angle from the first to get the altitude of the sun at the summer solstice, and we have 6°. Consequently at that season the shadow of the gallery roof would just strike the south end of the gallery floor. A curious astronomic coincidence, you say. But go a little further. Let us calculate the angle from this same coping down to the end of the central incline on the gallery floor. It comes out 36° 10′. Now at the winter solstice the sun was 30°+24° from the zenith or 54°, that is, 36° from the horizon, the angle just found. In midwinter then the sun shone just to the bottom of the effective gallery, as at midsummer it had marked its top. Between these two extremes the shadow must always fall. Thus the gallery's floor exactly included every possible position of the sun's shadow at noon from the year's beginning to its end. We thus reach this remarkable result that the gallery was a gigantic gnomon or sundial telling, not like ordinary sundials the hour of the day, but on a more impressive scale, the seasons of the year.

That the gallery itself extends below the point where the central incline drops vertically to permit of entrance to the Queen's Tomb with its ramps notched, as

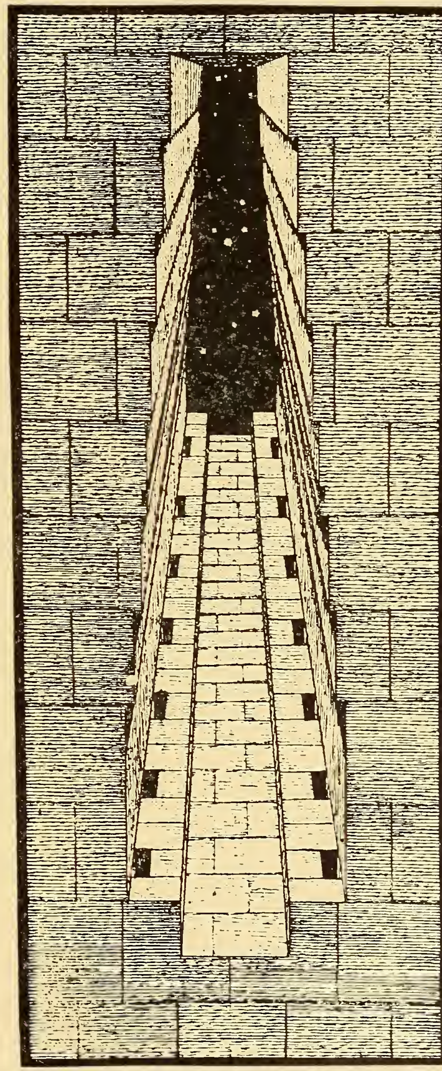
above, does not vitiate the deduction, for observers could not generally be placed on benches with their legs hanging down, however they might be so located on emergency. The recognition of this function of the gallery is not new, being, I believe, due to Proctor, but the exact coincidence of the limits of the effective gallery with those of the sun has, to my knowledge, never been pointed out.

Such, then, was the use of the entering passage, and such the design of the Great Gallery. Grand as was communion there with the sky by day, it must have been sublime at night—alone with the stars in the heart of that superb monument of stone. About the year B. C. 3430 it was further heightened by a spectacle which could not be witnessed now. Calculation shows that the great star α Centauri, the brightest and nearest to us of all the fixed stars, shone then at its upper culmination night after night down the hushed and polished vault of the Great Gallery.

α Centauri now hardly peeps above the pyramid's horizon at its highest, and in a few more years will never rise there at all until, thousands of years hence, the pole in its majestic precessional march raises it into view once more.

In a peculiar sense the pyramid was the man for whose use it was built. Primarily its purpose was to cast his horoscope through life, and then when his days were ended it became his tomb. He was buried in its interior. What had been its astrologic platform on top was continued on to an apex and then the whole structure sealed up, to remain, so it was fondly hoped, inviolate through time.

One reflection well worth our thought the pyramids suggest: the enduring character of the past beside the ephemeralness of our day. We build for the moment; they built monumentally. True we have printing which they had not. But libraries are not lasting. Fire accidental or purposive has destroyed the greater part of the learning of the far past and promises to do so with what we write now; and what escapes the fire, mold may claim. Only that idea which is materially most effectively clothed can withstand for long the gnawing disintegration of time. The astronomic thought of the pyramid builders lives on today; where will record of ours be, I wonder, five thousand years hence. We may be quoted indeed with ever-increasing inaccuracy of transcription, but the star priests of α Draconis's time speak in their own words still.



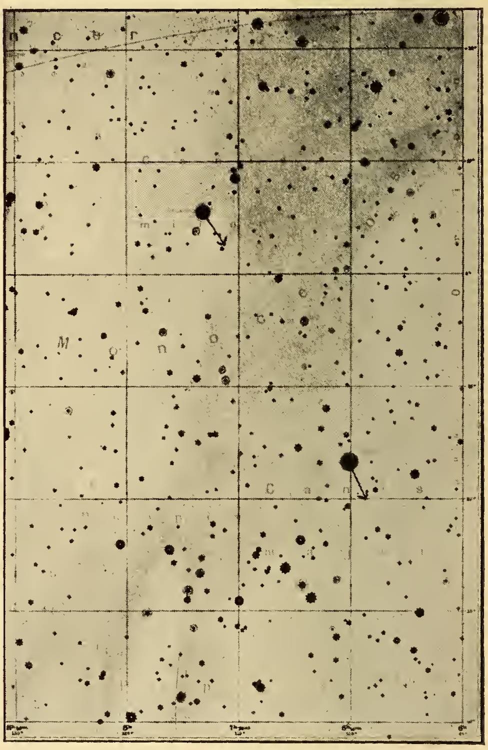
Vertical Section through the Grand Gallery.

To us Cheops is hardly more than a

name; long since his ashes were scattered to the winds; but the building those old Chaldean soothsayers constructed for him remains, not only today the grandest monument of man but the oldest and most significant astronomical observatory the world has ever had.

Now it has probably seemed to you that we have gone a long way back together—fifty-three hundred years—and we have found not savages, but scientists; we have found men, who, though practicing as astrologers for human good and ill, nevertheless were practiced astronomers as well, who knew immeasurably more about the subject than most persons today. To be confronted with such men of fifty-three hundred years ago may well cause us to open our eyes. I shall, however, carry you very much farther back still, for it occurred to me to add to this lecture tonight the oldest bit of history in the world, one that goes back so indefinitely far that it staggers imagination. It is a tale repeated by Al-Sufi. Al-Sufi was the great Persian astronomer of the tenth century. He wrote a "Description of the Fixed Stars" in Arabic a most valuable book which has come down to us and in it he gives an immemorial story about Sirius, Procyon and Canopus: Suhail (Canopus) had two sisters, Al'abûr (Sirius) and Al-gumaisâ (Procyon). Suhail married Al-djauza (Rigel) and seems to have had some domestic infelicity for he considered the best way out of his trouble was to kill her. By so doing he seems not to have angered any of her relatives—perhaps she had none—but his own two sisters Sirius and Procyon. Fearing their wrath, he fled toward the south pole, followed across the Milky Way by Sirius; while Procyon, remaining behind on the further side of the Galaxy wept till her eyes became weak. Hence it is that Sirius is called Al'abur, or the one that has crossed over. That is Al-Sufi's story as given by the late Mr. J. Ellard Gore. Now, you will notice here first, that Sirius, Procyon, Rigel and Canopus are the biggest stars in this part of the sky. Secondly that from Babylon, they were all visible. For Babylonia lies in latitude 32° and we can see Canopus from latitude 35° nowadays very easily.

Now comes a surprising bit of modern astronomic discovery. Within the last two centuries Sirius has been found to have a large proper motion, that is an individual motion among the other stars, and this, as Mr. Gore pointed out, is of such amount and direction as to have carried it in the last 60,000 years from one side to the other of the Milky Way and in the direction of Canopus. Procyon, as he further remarks, having the same general proper motion as Sirius and being now on the north side of the Galaxy, has always been there. Two very remarkable coincidences these, to say the least, of the results of modern science with ancient tradition; a tradition embalmed in the name of Al'abur, "the one who has passed over." For, mark you, Al-Sufi knew nothing of the proper motion of Sirius; still less those who preceded him.



The proper motion of Sirius and Procyon in the last 10,000 years

So that the tale could not have been invented to account for the fact.

This is not all. In consequence of the precession of the equinoxes Canopus swings around a curve the north and south axis of which is about 47°. It is at the present time as far north nearly as it ever can be and this was also the case 25,000 years ago, such being the length of the great precessional period. For the last 12,500 years it has been coming north, during the 12,500 years before that it was going south. It must have disappeared from view in Babylonia something like 22,500 years since—and did the same at previous intervals of 25,000 years. A tradition that it has sought the south pole is best interpreted as meaning that it vanished from the Babylonian sky southward. This it did 22,500 or 47,500 or 72,500 years ago. This then dates the tradition in another way and one which quite agrees with the action. Rigel has practically no proper motion so that here again the tradition is borne out. We reach then this amazing conclusion: that we have in this seemingly fantastic tale a tradition which is strictly in accord with several astronomic facts which were quite unsuspected till within a relatively short time.

Now I submit it to your own judgment: Could such a story possibly be made up with all its particulars, particulars so coincident with one another and with subsequent discovery. If not, then we have a bit of history dating from the stone age. And from such an age it is precisely the kind of lore we should expect to be transmitted. For watching of the stars is one of the oldest occupations of man, and any tales about them were sure to be handed down from one generation to another. Nor is anything so enduring. Think how the poems of Homer were preserved; all by word of mouth. For every mother tells such folklore to her child and the child remembers it as a man might not to tell again in turn. Extrinsically then the story would be likely as intrinsically it is true. Most probably then in it we have our oldest bit of history, an echo come down to us from the stone-age times.

THE EVOLUTION OF THE HORSE

Some idea of the immense lapse of time that has taken place to evolve the Eocene Hyracotherium into the modern horse is shown by Prof. H. F. Osborn as follows:

"The Rocky Mountains, it is true, began their elevation during the close of the Age of Reptiles; they had only attained a height of four or five thousand feet when the Age of Mammals commenced; they continue to rise during the entire period. But consider the map of Europe and Asia at the beginning of Eocene times and realize that the great mountain systems of the Pyrenees, the Alps, and the Himalayas were still unborn, level surfaces in fact, partly washed by the sea. . . . The birth of the Pyrenees was at the beginning of the Oligocene. At this time Switzerland was still a comparatively level plain, and not until the close of the Oligocene did the mighty system of the Swiss Alps begin to rise. Central Asia was even yet a plain and upland, and only during the Miocene did the Himalayas, the noblest existing mountain chain, begin to rise to their present fellowship with the sky. In North America, again, since the close of the Eocene the region of the present Grand Cañon of the Colorado has been elevated 11,000 feet and the river has carved its mighty cañon through the rock to its present maximum depth of 6,500 feet.

Those who have been impressed with a sense of the antiquity of these wonders of the world, and will imagine the vast changes in the history of continental geography and continental life which were involved, will be ready to concede that the Age of Mammals alone represents an almost inconceivable period of time."

The state engineer of Oregon has submitted a project for the largest water power installation in the world. It will develop 300,000 continuous electric horse-power at Big Eddy on the Columbia River. The hydro-electric units will be 32,000 horse-power each. It is estimated that the total cost will be about $23,000,000.

THE PHENOMENA OF CATALYSIS

REMARKABLE RESULTS PRODUCED IN CHEMICAL REACTIONS BY THE MERE PRESENCE OF CERTAIN SUBSTANCES WHICH UNDERGO NO PERMANENT CHANGE

BY W. R. WHITNEY

THIS is a purely chemical term and stands for the process of greatly increasing the velocity of chemical reactions by employment of materials which are not consumed in the process. Any analogy is apt to be misleading, but Ostwald suggests the parallelism between catalysis in chemistry and the effect in mechanics of the change from a too thick to a good lubricating oil on a shaft rotating under constant force. The speed will increase without application of additional energy. In a sense, this definition is too academic. In most of the processes called catalytic, the velocity-increase is so enormous that, without the catalyzing agent, the process would hardly take place at all. For this reason a catalyst is sometimes defined as any substance which *produces* a chemical action without being consumed in the process.

Catalysis is usually limited to describe cases where a definite material, or even a definite form of material, seems to bring about a reaction or produces a great increase in the velocity of the reaction. Heating the reagents produces great increase in velocity of most chemical reactions, and some are made to speed up by the effect of light, and so heat and light are sometimes called catalyzers. But it is customary to consider this type as at least partially understood and to class under catalysis the less easily explained cases, where the mere presence of some *material* apparently does the work and is yet not consumed. It acts more like the trigger of a gun. This sets off the reaction, which in our gunpowder analogy would otherwise be an exceedingly slow oxidation. The gunpowder might take a century to oxidize unless it were set off, although the products of the reaction would be the same regardless of the velocity.

It is very probable that for years catalysis was a word used, as such terms are often used, to classify or group together, without further commitment, a number of different phenomena which were not at the time explicable. It was known that hydrogen and oxygen could be mixed and would remain inert indefinitely, but that a little platinum or an electric spark in the presence of the mixture would cause rapid combination to form water. A finite quantity of platinum was able to produce the reaction between an unlimited quantity of these gases. Other finely divided metals acted similarly. The platinum was called the catalyzer. The spark in such a case was not usually considered as a catalyzer in the narrower sense. This is probably because the case is an application of intense heat which in any other manifestation is equally efficacious. It has been the custom to consider as cases of catalysis only those reactions in which the phenomenon can be ascribed to some material, thus excluding greatly increased reaction velocity due to light, high temperature, etc. It was known, on the other hand, that the decomposition of hydrogen-peroxide solution was greatly hastened or made almost instantaneous by colloidal platinum and other colloidal metals. Here again the metal was not consumed and had not lost any of its power after it had apparently accomplished so much. It was known that sugar in aqueous solution is ordinarily decomposed by the water into dextrose and lævulose with exceedingly low velocity, but the same reaction takes place very rapidly in presence of acids or certain organic ferments. Thus

the acid and the ferment were called the catalyzer.

It is known that many of our most common chemical reactions owe their velocity to the presence of water. In fact, water is the most common and most important catalyzer of all. It is much easier to find cases of chemical reactions which need water for any appreciable velocity, than it is to find reactions which can proceed in its absence. Yet in most of them the water apparently does not take part in the reaction nor is lost through it, and the same water could be used to an unlimited extent. Practically all of the common chemical reactions are of this type. Silver nitrate and sodium chloride do not react in the dry state, and the mere condition of solution is also not a criterion. While these two react readily when dissolved in water, they need not react appreciably when dissolved in some other solvent. This catalytic action of water, so common as to be usually lost sight of as a case of catalysis, is a very marked case because of its sensitiveness. The most refined methods have had to be employed to remove the water in cases where its effect was to be studied. For example, the ordinary explosion of carbon monoxide (CO) with oxygen does not take place if the gases are perfectly dried, but a trace of moisture makes it easy to start the reaction by a spark. Such active agents as gaseous hydrochloric acid and ammonia, which combine readily at ordinary temperatures, do not react in entire absence of water. And the decomposition or dissociation of ammonium chloride which in any ordinary experiment is readily brought about by moderate heating, will not occur in absence of traces of moisture.

The method of action may not be the same in these various cases, but the resulting great increase in velocity of action or even apparent production of the possibility of reaction and the non-consumption of the foreign matter or catalyst is common to them all. There are many other such reactions.

The various types of catalysis apparently differ widely, and while they possess in common the peculiarity which coördinated them under this head, they are being subdivided and grouped under new classifications because differentiating characteristics become gradually better understood. For example: there is a large group of chemical processes which are catalyzed by the presence of solids; sometimes by a specific solid, such as platinum, in other cases by a particular state or property of a solid, such as fine subdivision or large surface area, etc. A little palladium or osmium will ignite illuminating gas at the burner-tip in air. Some platinum, vanadium oxide, or even iron oxide will bring about the rapid union of sulphur dioxide and oxygen. These may be classed as surface effects, as absorption effects, etc., while it is not probable that reactions which owe their procedure to liquid or gaseous water can be so classed.

A number of catalyses may be looked upon as being due to the formation, for a short time, of products containing the catalyzer and one or both of the reacting substances, the catalyzer later stepping out of the reaction at its completion, much as the marrying parson leaves the wedding ceremony with his marrying power undiminished. In such cases it seems necessary to grant that the time necessary for the catalyst to unite with one of the reagents, and for the second to enter the reaction and the catalyst to back out, so to speak, is in all shorter than the time necessary for direct union of the reacting substances. This is possible. The catalyst often seems to be merely a means of in some way reducing the delays in a process. It can hardly be said to reduce the resistance to reaction, for reduction of resistance should cause a change in the total heat evolved by the reaction, and this does not occur.

Any treatment of this subject would be incomplete which did not mention the phenomenon of anti-catalysis or negative catalysis. As the name implies, this is the case where the presence of some otherwise inactive substance retards or prevents a reaction which would otherwise take place. In biological chemistry there are many such cases, and they are frequently referred to as poisonings. One

of the best known inorganic cases is that described by Bredig, who found that while the decomposition of hydrogen peroxide was catalyzed by colloidal platinum, iridium, etc., the presence of almost any one of the common soluble poisons was capable of destroying the action of the catalyst and of preventing the reaction. Hydrocyanic acid, hydrogen sulphide, arsenic, copper salts, etc., are such poisons. These poisons also act as anti-catalyzers to a number of biochemical reactions, ferment actions, etc. Water in most cases is an active catalyzer, but a few cases have been found where it is distinctly an anti-catalyst. Oxalic acid, dissolved in dry sulphuric acid, decomposes very rapidly, but the presence of traces of water greatly diminishes the velocity. The hydrogen ion is a generally active catalyzer. It shows its power in many cases of hydrolysis and in the action of enzymes, etc. The hydrolysis of cane sugar by acids depends upon it.

A multitude of reactions for which solid catalyzers have been found may be represented by one or two specific cases. Ammonia and alcohol vapors combine rapidly in the presence of heated thorium oxide, so also do phenols and alcohols. Titanium oxide and other metal oxides catalyze organic reactions without there appearing to be any predeterminable predilection. One is led to imagine that every possible chemical reaction has its specific catalyzers. Haber has said that every solid substance exerts some accelerating action on gaseous reactions, though some do it much more markedly than others.

It may be that all cases of catalysis are to be looked at as brought about either by the formation of intermediate chemical compounds of the catalyzer with one or both of the reagents and the subsequent breaking down of such compounds to the final reaction products, or of physical adsorptions corresponding to the increasing of concentration of one or more of the reacting substances.

The chemical industries are full of the most interesting and successful catalyses. Sulphuric acid manufacture has always made use of catalyzers in some form. In the early days it was the nitrogen oxides, and now it is platinum sponge, etc. When sulphur is burned in air, or oxygen, the dioxide is produced, and this, even in the presence of excess of oxygen, does not seem inclined to continue in the process of oxidation to the state of trioxide at any measurable rate. Yet this is the direction it should proceed, and any one of several triggers or catalyzers will effect it. It is very important to note that the final state of all of these catalyzed reactions is the "natural" state; that is, no consumption of energy is needed to reach the state, and energy is evolved by the process. The sulphur, in burning, *tends* to become the trioxide. Under normal conditions it only reaches the dioxide state in measureable time, but contact with such a solid as platinum sponge will catalyze the reaction, thus producing with great rapidity sulphur trioxide (the anhydride of sulphuric acid).

The great German dye firm, the Badische Analin u. Soda Fabrik, made careful study of catalyzers for the reaction between hydrogen and nitrogen by which they hoped to and finally did make ammonia commercially. The reaction was a perfectly possible one, but without catalysis it was always too slow to be practical. Finely divided iron, manganese, molybdenum, and tungsten were all found to be effective, and it was further found that these catalyzers could easily be poisoned by some reagents, but could be benefited by others. Thus arose the term "promoters" in catalyzers. A small quantity of some substance, such as an oxide, for example, serves as a promoter to the catalytic action of iron on the ammonia synthesis. Thus a practical and commercial process for direct synthesis of ammonia has been brought about. This reminds one somewhat of the complements and the immune bodies which, while coöperating in the blood, produce the effects of immunity.

There seems to me to be one simple way of looking at all catalyzers which is useful if it be not used unfairly. The velocity of reactions depends on the concentration of the reacting particles (molecules or ions, or whatever they may be). It is

not difficult to find in all cases of catalysis the probability of an increased concentration which is attributable to the catalyst. This is plain in such a case as platinum sponge and surface or solid catalyzers, for the absorption and adsorption of gases in such cases are well known. It is only a step along the path of this illustration to see possible intermediate physical and chemical compounds as concentrations of one or both of the reagents. Solid thoria catalyzes many organic reactions, so also does dissolved aluminum chloride. In the former case the physicist would grant the formation of adsorption compounds, and in the latter case the chemist recognizes the temporary formation of intermediate chemical addition products with the aluminum chloride. If we look at these two cases as cases of increased concentration of the reacting reagents, the possibility of coördination is clear.

The reactions in living matter (plant and animal) are very commonly catalyzed. Many of the catalysts have been named and have been isolated in more or less pure form. Malt diastase, which brings about the dissolving or hydrolyzing of starch, is such a catalyst. By its action in the germinating grain or seed, the reaction of the break-down, dissolution or solution of the starch is made rapid. The starch would be useless without this catalyst, and it is not used up by the reaction. This process is not confined to the cell or seed. It may be carried out in the laboratory. For example, a large mass of nearly solid starch paste may be made to rapidly liquefy by the introduction of a very small quantity of diastase. The enzymes ptyalin, invertin, emulsion, pancreatin, pepsin, and a score of others, are quite analogous. They each catalyze some reaction characteristic of some living process. Albumen and similar albumenoid matter is rendered soluble or assimilable by the catalytic action of pepsin, for example. The reaction is not a simple one between the pepsin and the albumen, but the latter causes the albumen to react with the water present and hydration occurs. A perfect explanation of this catalysis in life-reactions is probably not yet possible, but in looking for analogies of our apparently simpler cases, we are struck with the force of the fact that these digesting catalysts are known to absorb on, or absorb in the organic matter whose dissolution they catalyze. For example: if fibrin be suspended in gastric juice (which contains some of these organic catalyzers or enzymes), it can be shown that they leave the solution and are absorbed by the fibrin in which they are producing the decomposing reaction. They thus resemble the reacting gases which adsorb in the platinum of our simpler cases.

An exceedingly interesting recently investigated case of catalysis in the relatively simple reactions of the laboratory, corresponds so perfectly to a well known and apparently complex historical case in Nature that I make bold to present it.

It may be recalled that in that remarkable biochemical work of Pasteur's in connection with a study of the tartrates, he found that in the crystallized tartaric acids there were left and right crystals, shapes which corresponded as our left and right hands do and would not permit of even imaginary superposition. So also, when these were in separate solutions, one caused rotation of the plane of polarized light to the right, and the other to the left. When they are suitably mixed they form the optically inactive racemic acid. One of the ways, which he discovered for separation of these two forms when found thus mixed in Nature, was by means of the green mould pencillium glaucum. The growth of this mould caused decomposition or destruction or oxidation of one of these exceedingly similar chemical compounds (identical in quantitative chemical composition) more rapidly than the other; it showed such a selective catalysis as to distinguish between the two. This was a case of selective catalysis by the enzyme or ferment of the growing mould. Starting with the racemic, or optically inactive acid, he could stop the fermentation at a stage where only the lævo tartaric acid remained, the dextro tartaric acid having been destroyed.

Now quite recently, Bredig and his pu-

pils have studied the reaction of decomposition of bromcamphorcarbonic acid when catalyzed by small quantities of organic bases such as the alkaloids. They seem to have thus produced results very perfectly paralleling the above historic discoveries of Pasteur.

The molecular structure of the tartaric acids is such that, knowing this structure and knowing that an asymetric carbon atom will produce optical activity, it is now possible to predict such developments as the separation of some optically inactive material into two optically active ones. It was shown that in the decomposition of bromcamphorcarbonic acid, the organic alkalies act as catalyzers. This substance decomposes slowly into bromcamphor and carbonic acid. The process is catalyzed by organic alkaline bases, such as analin. The bromcamphorcarbonic acid has two optically active forms corresponding to the left and right tartaric acids of Pasteur. Both of them are catalyzed equally by optically inactive bases, but one of them is more rapidly catalyzed than the other by chinin as catalyzer, and the other is more rapidly catalyzed by chinidin than the one. Chinin and chinidin are themselves optically active substances, and thus it is found that an optically active catalyzer is capable of differentiating in catalysis between two optically active compounds and can catalyze the decomposition of one of them more than that of the other in a mixture of both, as Pasteur found with penicillium glaucum and the tartaric acids.

FROZEN MINE SHAFTS

In 1860 when the coal mining industry in Holland came to be seriously considered it was found that in the coal layers, except in two of the medieval mines near Kerkrade, there is a stratum of drift sand that contained quantities of water so great that it was not possible to build shafts that had any considerable depth. It was not until 1883 that Poetsch invented the "Freezing Method" which made it possible to reach these coal layers lying at a depth of three hundred to one thousand feet.

On the spot where the shaft is to be dug, from 25 to 30 borings are made down through the drift sand to the solid rock in a circle five feet larger in diameter than the projected shaft. Pipes are then sunk into these boreholes, and through these is circulated, by powerful freezing machines, a chemical solution cooled down to minus 20°. In this way the drift sand containing the water is frozen as hard as a rock after the freezing machines have been working day and night for two months. In this frozen cylinder of sand a shaft is then dug and lined from bottom to top with strong segments of cast iron securely soldered together.

The freezing method, thus applied, has successfully solved the problem, and Holland now has a flourishing mining industry.

TRANSPORTING LIVE FROZEN FISH

In extreme northern latitudes notably in Siberia, some of the great rivers are frozen solid to the bottom but the fishes thus imprisoned are not killed but resume active life when the ice melts in the spring. The *Fischerei-Zeitung* has been discussing experiments with the freezing of live fish for transportation, bringing up Pictet's experiments where fresh-water fish were put in a tub of water kept at the freezing point for twenty-four hours and then allowed to freeze slowly into a solid block of ice. This was afterwards cooled slowly to −4° Fahr. On melting the ice, even as long as two months afterward, the fishes swam about without showing any ill effects from the experience.

With reference to what can be done with the transportation of fish in this manner, cakes of ice with fish frozen in them have been wrapped in cloth and surrounded with heat-insulating material, in which condition they can easily be shipped. It is necessary to thaw the ice very slowly and to keep the water near the freezing point for several hours in order to preserve the life of the fishes.

SOME RELATIONS OF FLIES AND MOSQUITOES TO MAN

CONDITIONS UNDER WHICH THE GERMS OF INFECTION ARE SPREAD BY INSECTS—INSECT-BORNE DISEASES FOUND TO BE INCREASING

BY HARRISON G. DYAR

RECENT investigations have shown that certain insects have an important relation to disease. Not all diseases are related to insects, but the number found to be so is increasing. Diseases must be due to specific organisms in order to be conveyed by insects, and these divide readily into two classes. First, the bacterial diseases, or diseases caused by certain bacteria, such as typhoid fever, tuberculosis, anthrax, etc. The bacteria are simple organisms, without complex life-cycle, multiplying by simple division, their only modification being spore formation as a resting stage. The conveyance of these by insects is a purely mechanical one and essentially accidental. It is safe to say that the usual, normal mode of transference of such diseases is not through the agency of insects. We refer to such cases as the carriage of typhoid fever by the house fly. The usual mode of transference of this disease is by the contamination of water or food by the dejecta of former cases of the disease. In exceptional cases only is the house fly an important factor, where there is close proximity of exposed dejecta and exposed food.

The conditions are slightly different where the transferring insect pierces the skin, as for example with the stable fly. Here inoculation of pathogenic bacteria may occur, such as would be harmless by ordinary ingestion. In this class is the case of the transference of infantile paralysis by the stable fly recently investigated. The general condition is, however, the same. The nature of the transference is essentially accidental. It is quite true that these special cases may become of high importance and the transference frequent and dangerous, where the special conditions are repeated. Yet the nature of the transference remains accidental—it has no necessary relation to the life history of the parasite.

In the second class of cases the diseases are caused by protozoa, or forms of life still higher than these. The protozoa are organisms of some complexity, with definite life-cycles. All the organisms of this class are obligatory parasites, with alternate life-cycles, one passed in some insect, the other in some vertebrate. Without this alternation the parasite cannot continue to exist. The carriage of the disease by the insect is, therefore, not accidental, but a necessary step in the life history of the parasite. Each disease of this class has its own specific parasite, and the parasite is closely restricted in its hosts, generally but one species of insect and one vertebrate. For example, yellow fever, which passes one life-cycle in a certain mosquito, *Aëdes calopus* Meigen, and the other cycle in a certain vertebrate, man. The relation of the insect to the vertebrate must be a close one, or the alternating parasitism could not continue, nor could it ever have arisen. In the example cited, *Aëdes calopus* is a domestic mosquito, breeding in artificial receptacles of water and closely associated with habitations of man throughout the warmer climates. On account of the characters of this mosquito, being confined to warm climates below the frost line, the disease yellow fever is essentially a tropical one and only under exceptional circumstances can become prevalent in northern countries.

There is reason to suppose, although the matter has not been as fully worked

out as could be wished, that malaria is nearly as restricted in its hosts as is yellow fever. We find three types of malaria. Of these it appears that the common tertian malaria and the rarer quartern are conveyed by the mosquito *Anopheles quadrimaculatus* Say only, the pernicious malaria, by *Anopheles crucians*, Meigen, while *Anopheles punctipennis* Say, our commonest species, does not carry malaria at all. It therefore becomes important to distinguish between these mosquitoes and to collect full information as to their habits. The three species of *Anopheles* are very much alike and have similar breeding habits, yet there are differences. *A. quadrimaculatus* and *A. punctipennis* are well distributed throughout the eastern United States, extending their range to Canada. The tertian malaria is known practically throughout the range of *A. quadrimaculatus*, but the quartern does not accompany it so far to the north, perhaps on account of its comparative rarity. The same is true of *A. crucians* and the pernicious malaria, the host extending its range further north than the parasite seems capable of existing. It follows that in the northern states there is only one species of *Anopheles* carrying malaria, namely *A. quadrimaculatus.*

The breeding places of the larvæ differ in character in a general way. *A. crucians* prefers pools near the sea, slightly saline; *A. punctipennis* breeds in rain puddles and collections of water in various receptacles, cold springs, and to a less extent only in ponds, warm marshes or rivers; *A. quadrimaculatus* prefers warm permanent marshes containing algæ, sluggish streams or edges of lakes. I have never bred *A. quadrimaculatus* from the small temporary collections of water often found full of *Anopheles* larvæ and hastily pronounced dangerous to health.

It will be seen that exact studies of the particular insect concerned in the transference of each disease are essential in order that efforts to combat that disease may be effective. General measures against groups of insects will generally result in wasted effort, and especially if the climate remains unconsidered. For example, in Boston, measures directed against the breeding places of mosquitoes in chance receptacles of water, cisterns, barrels, puddles in waste land, etc., though laboriously and fully carried out, will not result in the reduction of any disease, for the *Culex pipions* that breeds commonly in such places, is not a carrier of any disease affecting man, while the *Anopheles punctipennis* breeding in the same places does not carry the tertian malaria, the only form of malaria prevalent there. On the other hand, in Havana, the same measures transform a pestilential city into a sanitary one, for *Aëdes calopus* breeds only in such places, and its elimination or sufficient reduction means the elimination of yellow fever; *Anopheles albimanus* also breeds there, and it is the principal, or perhaps only carrier of the forms of malaria common in our tropics. Again *Culex quinquefasciatus* inhabits such places, and only such. Its sufficient diminution means the elimination of filariasis and its following disfiguring elephantiasis. A tropical city without yellow fever, without malaria, without filariasis and in addition without mosquitoes to annoy by night or day, has been robbed of its worst terrors, and can be obtained by the prohibition of standing water, unprotected by screens, within the city limits.

While flies and mosquitoes are not the only insects conveying disease, they are responsible for the majority of cases. Aside from their rôle in this matter, they become important to man on account of their annoyance. No one cares to dine in the midst of a swarm of flies, crawling upon his person and over the viands, while the plague of mosquitoes in many of our cities in summer renders sleep difficult or impossible. One cannot visit a public park, or even his own lawn in the evening without perpetual activity to drive away these insects. Many otherwise attractive summer resorts are neglected or deserted from the presence of woods mosquitoes or salt marsh mosquitoes. The conditions in the cities could be so easily mitigated by a little well directed activity on the part of the

city authorities that it seems a shame that the citizens should be subjected to them. These mosquitoes belong to only two species, *Culex pipiens* L. and *C. quinquefasciatus* Say, neither of which breeds at large in natural collections of water, but only in the receptacles supplied by men. In cities such as we have in mind where there is municipal water supply and sewers, they breed in the cesspools small and large, but principally in the basins at the street corners used for retaining the heavier street dirt from entering the sewers. The occasional breeding in neglected tins or other articles is too small to affect the supply and can be disregarded. The protection of sewer traps by screens, the occasional oiling or periodic flushing would prevent the breeding of these mosquitoes, yet year after year the plague continues, thousands of citizens flee to the dubious delights of summer resorts, while those forced to remain have life made miserable by nightly torments and their vitality reduced from loss of sleep, or else suffocate under nets.

In summer resorts outside of cities the conditions are different. Other species of mosquitoes are involved, with other habits. In resorts upon the sea shore affected by mosquitoes, the salt marsh forms are concerned, *Aëdes sollicitans*, *A. cantator* and *A. tœniorhynchus*. These breed in the temporary salt water pools near the sea, and the adults fly long distances, often troubling communities many miles from the breeding places. The only remedy for these species is the reclamation or ditching of the salt marshes.

Summer resorts situated in the woods or mountain districts distant from the sea may be troubled by woods' mosquitoes. These are never troublesome in the open, nor in houses not surrounded by trees. But persons visiting the woods for pleasure may be considerably inconvenienced by them, and in such houses as are closely surrounded by trees they may be annoying on the porches. Some eight to ten species are involved, all having similar habits, breeding in the early pools formed by the melting snow. The adults live some three months after breeding is finished, gradually diminishing in numbers throughout the summer. These mosquitoes may be combatted by filling or draining the hollows where the snow-water accumulates; but only in exceptional cases are the results worth the cost and labor of the operations.

The amount of personal annoyance caused by the house fly is of minor importance. The fly is quiet at night, and so does not disturb sleep. It does not bite. Its control, however, is most desirable, though not of the vital importance of the true disease-carrying insects. The control may be effected by proper sanitation of stables, protecting the horse manure from access by flies. While the house fly does breed in other substances than horse manure, this is its principal food, and treatment of this should prove effective. In combating insect-borne diseases, the extermination of the insect-agent is never necessary. Simply its reduction in numbers to a minimum where the general transference of the disease can no longer occur. The life of the parasite is conditioned on an abundance of both of its alternate hosts, and if either fails in numbers, it must cease to exist. The disease is then exterminated for that given locality

THE ALUMINIUM INDUSTRY

Although the early expectations of the wholesale substitution of aluminium for steel and iron have not, for very good reasons, materialized, it has shown such a perfect adaptability to certain of the arts that the demand for this metal has grown enormously. From a production in the United States of less than 100,000 pounds in 1883, in 1893 the output had grown to 350,000 pounds, in 1903 to 7,500,000 pounds and today it is in excess of 50,000,000 pounds. At the present time the use of aluminium in the place of copper has created a great temporary demand. New methods of reduction are being tried that promise a cheaper and more abundant supply.

THE DOCTRINE OF "FITNESS"

In his recent course of Lowell Institute Lectures, Prof. Lawrence J. Henderson of Harvard University discussed quite at length the subject of "Fitness." He brings to attention the fact that in general the consideration of fitness has been purely from the side of the organism, the suggestion being that organisms adapt themselves to the environment or that they survive when they are able to be in harmony with their surroundings. Professor Henderson looks at the other side of the Darwinian shield and in his initial lecture said "the hand fits the glove and the glove fits the hand; the bird fits the air and the air fits the bird. Fitness is mutual. In general a one-sided view is taken and it is the fitness of the organism to its environment that is most commonly argued, but the fitness of the world for life is as important as the fitness of life to the world." The series of lectures was devoted to pointing out the qualities in the world which make life possible and without which life as we know it would be out of the question.

The general line of the argument was that the earth is a fair sample of the universe. The discoveries of astro-physics show the universal distribution of the elements known to the terrestrial chemist and the inference is clear that other suns and other planets are all composed of precisely the same elements and these are subject to the same changes with which the earthly chemist is familiar.

Energy in like-manner is evidently not confined to the earth alone. These two facts provide for the speculative biologist a field in which material is furnished for an investigation of the relationship between life and environment.

Outlining the factors essential to life, Prof. Henderson pointed out that there are necessary a complexity in the life itself, a regulation of the conditions about it and third, food. It is not now possible to conceive of life that shall be truly simple for already in its lowest forms there is much complexity. If life is to persist there must be a durability of mechanism and this can exist only when inner and outer conditions are stable. It is evident then that the regulation of temperature, of pressure, and of chemical construction of both the environment and the organism itself are essential factors, which for convenience were classed under the one term, regulation. Then a living being must be active, hence, its metabolism must be maintained by means of matter and energy so there must always be an exchange of these with the environment. The question then comes, "given an organism to which complexity, regulation and food are essential to life, what are the conditions of environment which can best supply them?"

In the consideration of what conditions are essential for life, Prof. Henderson finds that the substances that will be most abundant on the surface of a planet with its crust formed are water (hydrogen and oxygen) and carbonic acid (carbon) and the greater part of his discussion was with reference to the peculiar fitness of these elements by themselves and in their combinations for the maintenance of life. Some of the arguments were that water has very nearly the highest specific heat of any substance and is most important in the production of the temperature of environment which if life is to be preserved must be free from cataclysmic changes. The likelihood of stability of temperature is greatly favored by the presence of water in the environment. Water, furthermore, is one of the greatest solvents, so that the ocean contains a greater variety of substances than if it were of any other substance than water. This affects the variety as well as the quantity of food. In the organism itself the solvent power of water makes possible the complexity of the blood in highly developed creatures and is the prime factor in certain organs in accomplishing their work. Then it is true that in the separation of oxygen from hydrogen, in the tearing apart of water, there is the largest amount of heat stored in the products and these two gases are uniquely

favorable to be reservoirs of energy, all of which is important to the organism. Without the preponderance of water the earth would possess its physical properties to very little purpose so far as life is concerned. The chemical stability of water is of great consequence in organic and inorganic processes. It is the principal constituent of all living organisms and is taken into the bodies of the organisms in far greater amounts than all other substances combined. Water makes the earth habitable by securing uniformity of temperature. Its high specific heat, the latent heat of vapor and the heat given out when water freezes are great factors in producing this uniformity.

Evaporation is a tremendous operation which through water is working for the needed uniformity of conditions. There is nothing to compare with water as a solvent and it is remarkable in its ionizing power. Aided by carbonic acid all substances yield to water, and rocks in place suffer a slow destruction. In this way there is set in motion the great earthly circulation of materials. Furthermore, water does not exhaust itself in its work.

Thus Prof. Henderson led to his general statement that "water by its very nature as it occurs in the operation of cosmic evolution has a fitness for life no less marvelous and varied than that fitness which has been one of the processes of adaption in the course of organic evolution."

The speaker next recounted some of the fitnesses of carbonic acid. "This," he said, "is so seldom separated from water that it is hardly fair to consider them apart. They are together the common source of every one of the complicated products which are made by living beings." Carbonic acid is all-pervasive, soluble and when in combination with water produces a liquid singularly inert to alkalis and acids. Through the latter quality the oceans are almost always nearly neutral. With its aid protoplasm and blood possess an unvarying reaction. As a whole, carbonic acid is less various than is water and its fitness not quite so obvious, but the two make a pair admirably and uniquely fitted to their mutual work by intricate relations.

These claims were supported by the review of observations in which Prof. Henderson has been engaged for half a dozen years and the chemical and physical properties of many other substances were noted. The outcome of the whole investigation is that the earth or any other planet would not be habitable but for the existence of just the conditions which are the natural result. There are so many qualities adapted to the environment of life that Prof. Henderson comes finally to the belief that there is not one chance in millions of millions that the many qualities and unique properties could occur simultaneously in the elements of hydrogen and oxygen which constitute water, and carbon, excepting through the operation of a natural law that connects them. He believes therefore that some unknown natural law must have been at work but does not himself consider what it may be, saying instead "the discussion of the question is more philosophical than scientific, it is open to anyone who may desire to enrich the subject with speculations of any sort. He may follow Prof. Bergson and call it 'impetus' or he may term it natural theology or he may take a teleological view. No such discussion can contribute directly to the scientific knowledge of the underlying phenomena." J. R. JR.

"HARDENED COPPER"

Metallurgists who have examined the so-called hardened copper of the ancients find that it is not pure copper but is generally a natural alloy and in some cases an artificial one made by melting two ores, copper and zinc, together. The Monel metal, now largely used in the arts, is made from the natural copper-nickel ore found in the Sudbury mines in Ontario and can be used for cutting purposes. In the vicinity of the Sudbury mines many ancient implements have been found made of this native ore hardened only by hammering.

The cutting implements of ancient origin having the appearance of copper, were once supposed to be of pure copper hardened by some unknown process.

INTENSIVE CONSERVATION IN JAPAN

Before the Appalachian Mountain Club, at a recent special meeting, Miss Ellen Churchill Semple spoke with reference to the effect of natural conditions on the people of Japan. She showed how the insular position forced upon the inhabitants enormous economy and intensive cultivation of the soil. "It is a fundamental principle," said Miss Semple, "that agriculture shall be highly developed in islands. They are bounded by the sea and since the farms cannot be extended into adjacent countries as on the continents, the art of tilling the soil is most highly developed." The limitation of area is not the only misfortune of this island empire but there are others of structure and soil that make agriculture difficult. In addition to the large infertile areas occupied by the mountain chains there are the beds of most of the rivers. These are comparatively short streams which drop in a quick course to the sea and have cut as yet only V-shaped valleys in which the banks rise at once from the water and there are none of the great bowl-shaped valleys on the floors of which agriculture is possible. The run of these rivers in general is so short that comparatively little land has been built up along the seashore from their detritus, but at the same time, it is on these small coastal plains that most of the agriculture has been developed. The nature of the upland country is such that there are no pasture areas for cattle.

Miss Semple presented in striking form the intensive quality of agriculture necessary to the Japanese people. Although the area of the islands together is 148,000 square miles, the conditions of infertility make all but fourteen per cent. of this useless, so that, as a matter of fact, the fifty-two million people of Japan must be supported from the cultivation of lands not greater in area than three times the state of Massachusetts. In addition to this, of course, there are the products of the fisheries. Japan, it is true, imports much food but it must be remembered that the payment for this comes really from the soil so that the maintenance of the people is dependent on the agriculture.

The result of these conditions is first that it makes vegetarians of the Japanese, for no cattle are raised and the absence of stock affords to the farmer nothing whatever in the way of barnyard supplies. It has been necessary on this account to make use of the wastes of the teeming population and to conserve everything in the way of inedible vegetable products so as to return the needed phosphorus and nitrogen to the farms. The savings towards the enriching of the soil are marvelous to one brought up in so wasteful a country as the United States, for leaves are hoarded, tree twigs, the straw of the cereals, the grass that may be cut for the purpose, and coming down to such matters even as the filtrations of the family bathtub. In the use of human wastes for fertilizing, according to Miss Semple, the people have known for ages the principles that the great governmental schools of Europe and America are just beginning to discover.

The view that was given by this speaker, who is the world's most famous anthropogeographer, is little short of wonderful, and impressed the audience with the constant back-breaking handwork in caring for the farms. Machinery is absent and animals are used generally only in the plowing of the land. It is hand labor everywhere and largely that of women. The soil is literally pulverized between the fingers. The weeding of the farms is a daily occupation and in the intensiveness of the work is made to include everything but the most perfect individuals of the crop itself.

The average farm is little above two acres in extent. The farmers live in villages to save the waste of land which roads to separated houses would entail, so that means of communication are by rough trails and paths. The villages are

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practically on waste land and from each village which lies in the valley of a stream there is the great untenanted forest stretching over the ridge into the valley beyond. There are places more particularly on the coast in which the fishing industries have congested the population, and agriculture is carried on on large terraces which extend at times even to the tops of the mountains.

Two or three crops are the rule and the practice of sowing the second one before the first one is harvested is common. There is no waste for fences since the country is without cattle, the divisions between fields and the ridges between the little inundated spaces of the rice paddies are filled with beans or some other vegetable that will help toward the feeding of the people and even with these provisions, the margin between ordinary life and actual starvation is very small, and an unfortunate season with cold or lack of rain may mean famine. In this whole agricultural scheme silk has come to be an important element and may even double the farmers' income. There is work here for the whole family including the children for six or seven months.

With this unending labor and so little in the way of comfort, the people are smiling and happy. Miss Semple's observations in Japan should mean a great deal to the people of the United States in which even with its three million square miles there is already discussed the question of conservation. In Japan with fully half the population, economic principles and conservation have been able to solve the principle of actual life from an area only half that of New York or Pennsylvania.

HIGH WIND VELOCITIES

No anemometers have yet been made strong enough to withstand the severest wind storms and probably the highest velocity ever recorded by an anemometer was 186 miles an hour on Mount Washington, on January 11, 1878. This was made by an instrument of the Robinson type and is probably much in excess of the true wind velocity. In the annual report of the chief signal officer for 1875 an attempt was made to estimate the velocity of the wind in a tornado that year, from some of its more remarkable manifestations; as for instance, from the fact that a pine board was driven through a telegraph pole and another three inches into a tree. To produce such an effect would require a velocity of from six to eight hundred miles per hour.

PROTECTING PUBLIC HEALTH IN SMALL TOWNS

Coöperative health administration is a plan for smaller communities which the Massachusetts Institute of Technology has devised and which is being put into actual practice. The furnishing of a health administration for rural communities, especially those adjoining one another, has been taken up regularly by the department of biology and public health as one of its public services and this the Institute proposes to furnish to the towns at practically its cost.

There are certain obvious advantages in a plan like this; in the first place there may be secured what is exceedingly difficult under any other conditions, the establishment of a proper and efficient health policy in adjacent towns and uniform health regulations. Adjoining districts thus working together can, by their united purses, secure for themselves a quality in sanitary officers to care for their work that would otherwise be absolutely impossible. They can secure an attention to important technical details, like the taking and testing of cultures. Coöperation in this way would be of great importance in the determining of an outbreak of infection. A case or two of some malady scattered in each of two or three towns would attract no attention but if these all came to the notice of a central officer, who has his eye on half a dozen such towns, the number of cases would suggest to him an outbreak and give to him the earliest possible chance to limit its spread through preventive means.

It is true that in some states such matters as these are under the care of the state board of health but, at best, such supervision must be rather distant and its effectiveness at critical moments lessened.

In the securing of a well qualified man, technically trained for the coöperative health work of a number of towns, the question of local jealously will be no longer of any consequence. A single opinionated, stubborn practitioner will not then be able to dictate his health policy to the whole town and modern machinery carried on with the light of modern advances can immediately be applied.

When it comes to the details of running the health office it will be seen at once that there is a possibility of system in coöperation such as the individual town could never dream of and, so far as the expense is concerned, the divided cost of one good officer would impose on each town no greater burden than its present officer. In laboratory facilities more strikingly than in any other division, the advantage of having a central well-equipped establishment which may be almost instantly at the service of any town is beyond question.

The Institute has here originated a new and workable method of administrating public health in smaller places, applicable not only in Massachusetts where it has already been established but in all other communities desiring efficient health work. It is a beginning which has been watched closely for a number of months already, and the development of which will be of wide interest and importance.

A PRODIGY DUE TO DEFECTIVE VISION

A case is reported in the *Journal of the American Medical Association* of a man who had the power of reading a page of an ordinary duodecimo or octavo book at a glance. His eyes and attention were fixed on the book for a second or two and its statements or contents fixed in the memory.

The curious part of this is that this power of apprehension of a complete page was because of the loss of use of the central sensitive part of the right retina which had been destroyed by disease in middle life. The region about the destroyed spot increased its sensitiveness so much that it could clearly see all the border region of the printed page which to a person of clear vision, would appear blurred, owing to both eyes concentrating themselves upon a more or less fixed point on the page. L. E. M.

SCIENCE CONSPECTUS

VOL. III MARCH, 1913 No. 4

EARLY MAN*

THE STORY OF THE PHYSICAL DEVELOPMENT OF MAN FROM HIS EARLIEST RECORD AND OF HIS RELATIONS TO THE ANTHROPOID APES

BY HERVEY W. SHIMER

EOLITHIC

IT IS generally considered that earliest man is to be distinguished as man from other animals by the use of weapons and tools. With very primitive man these implements would be such casual sticks and stones as he chanced upon, and only later would follow a more and more careful selection of weapons better fitting the hand and more adapted to the use of defense and offense. Still later would it occur to man to improve this chance adaptability by the chipping off of inconvenient corners, so that the rounded ends might better fit the hands and the sharper edge perform more efficient service. To this slight alteration of stones, found ready at hand, would succeed the deliberate shaping of the flinty material into weapons and tools after a design existing in the maker's mind. And this first deliberate working out of a definite plan is taken as marking the first Paleolithic implement. To all the preceding stages of workmanship is applied the term Eolithic. (Fig. 1).

It is obvious that very low Eolithic culture would leave no incontrovertible trace of its existence. If, for example, the Semang of the Malay Peninsula were destroyed, one could not know of their existence from their stone implements; for since they apparently use only such as they chance to pick up these could not be distinguished from the other stones chipped by nature, which they had not used. Hence there has arisen much controversy among students of eoliths over the earliest geological time to which they may be assigned. Their occurrence in the Eocene is not now claimed but they have been found according to some students in the middle Oligocene of Belgium. More conservative opinion, however, recognizes no finds as true eoliths before those found in the upper Miocene of Cantal, France. According to the Belgian geologist Rutot, who has spent his life in the study of the Eolithic period, eoliths are found to be less and less shapely, as older and older deposits are searched, apparently showing evidence of less and less care in their selection by Eolithic man. So that it is possible before the period of transition from the Eolithic to the Paleolithic (Strepyan) to distinguish the descending series of Eolithic cultures,—Mesvinian, Mafflean and Reutelian. With this last period the eoliths are at their most primitive stage and all Tertiary eoliths belong to this culture period.

Up to the year 1907 these eoliths formed the only fully accepted evidence of the presence of Eolithic man. That year, however, parts of the skeleton of a

man were found in the sand pit of Mauer, near Heidelberg, Germany, while on December 18 of last year announcement was made to the Geological Society of London of a similar find in a gravel pit at Piltdown, Sussex, England.

The Mauer, or Heidelberg man (Homo heidelbergensis) (Fig. 2) was found in stratified, undisturbed, early glacial sands at a depth of seventy-nine feet below the surface; the upper thirty-five feet of this consisted of a later glacial deposit (loess). Associated with the human bones (a lower jaw) were, to mention but a few, remains of the straight-tusked elephant (Elephas antiquus) characteristic of the lower half of the glacial period, an upper Pliocene to lower Pleistocene rhinoceros (Rhinoceros etruscus), and a primitive horse. These fossils thus demonstrate that it was during the early part of the glacial period that man and these now extinct beasts lived, and that the ancient Neckar river depositing here its loads of sand brought also these bones.

This jaw would be classed as anthropoid on the basis of the great width of the ascending branch with the very slight notch at its top, and the retreating chin, but the teeth are so small as to be distinctly human and they form an uninterrupted series, with the eye teeth not projecting above the surface of the rest.

By far the most important quite recent discovery of remains of early man is the so-called "Sussex man," Eoanthropus dawsoni (Fig. 2). This is represented by portions of a single skull, found in gravel of early Pleistocene age. The cranium capacity is distinctly human, being about twice that of the highest ape, but the indicated arrangement of the superficial arteries of the brain is typically simian, as is also the lower jaw. This last somewhat resembles the Heidelberg jaw, but is less massive, with smaller molar teeth and with a still more receding chin.

These two finds thus give us some conception of Eolithic man. They agree in presenting those most prominent primitive characteristics,—the almost entire absence of a chin and the presence of a massive lower jaw, and in combining other primitive, ape-like features with distinctly human ones. It is the present trend of opinion, likewise, to class with Eolithic man though possibly as a distinct race, the remains of the famous Pithecanthropus erectus—an imperfect skull, two molar teeth and a diseased thigh bone—found 1891–92. These occur in the earliest Pleistocene or latest Pliocene deposits in Trinil, central Java.*

Early man is thus associated with the lower Pleistocene in Europe. This period was marked by the repeated rise and fall of temperature, and geographical conditions were quite different from those of the present. The chief geographic feature was the continental elevation because of which lands now isolated were connected. There was no North Sea nor English Channel; Europe and Africa were connected both across the Strait of Gibraltar and across Sicily; France and Southern England were a continuous land mass, as were Ireland and the rest of Great Britain.

Paleolithic

Geologists agree that there were during the Pleistocene several glacial advances alternating with interglacial warm periods during which the ice retreated and the climate was in some instances even milder than that of the same latitudes at present. These alternations of climate naturally caused alternations in the plant and animal life, and thus for immense periods of time man of central Europe was associated with arctic forms of life and again for other immense periods with temperate forms.†

It is usually considered that there were in central Europe four periods of cold—of ice advances, and three periods of milder climate—of interglacial ice re-

*According to Schuster (1911) the fossil plants from these beds, brought back by the two Selenka expeditions of 1906–1907 and 1908, are of lower Pleistocene age.

† It has been suggested that as the modern anthropoids live entirely upon fruits and vegetables so likewise did early man and that for Europe at least the change from such a diet to one of mostly meat was due to the killing off of the tropical vegetation because of the advance of glacial conditions. Man would thus be forced to adopt more and more an animal diet.

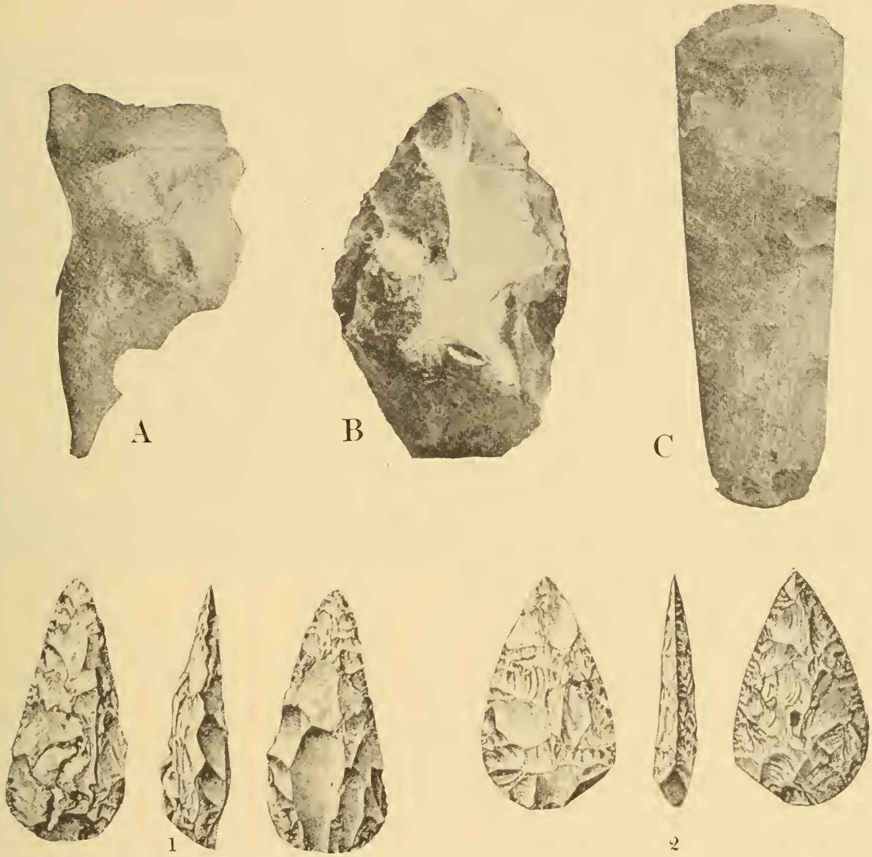
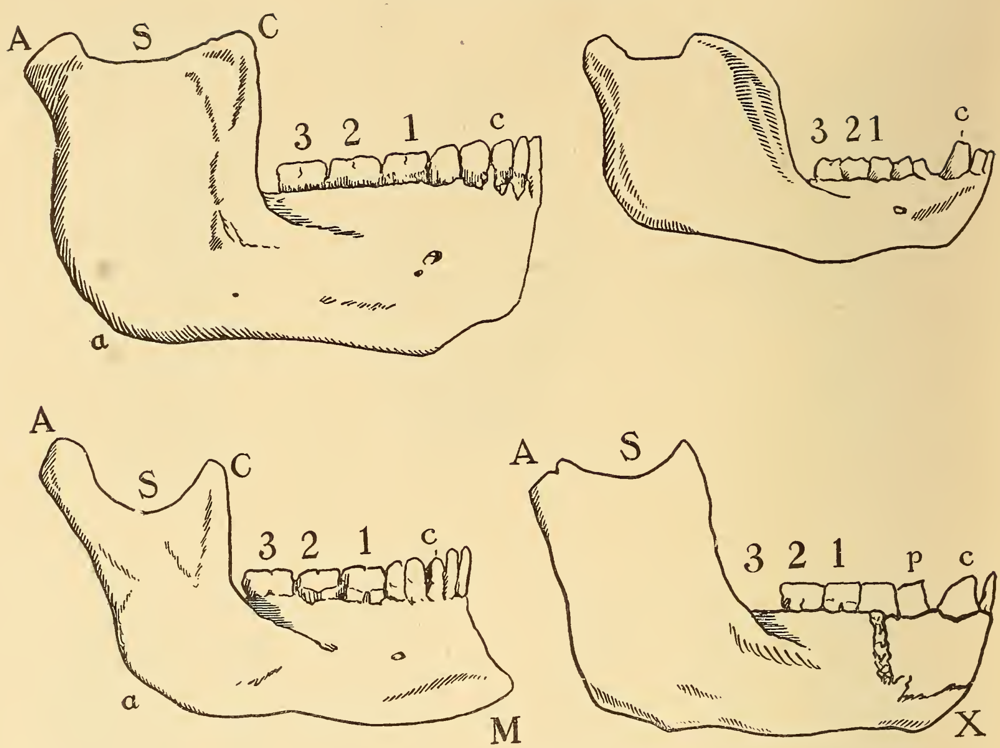


Figure 1—A. Eolith, Mafflean Culture Epoch, Belgium. B. and 1. Paleoliths, Chellean Epoch; the former from Kent, England; the latter from Chelles, France. 2. Paleoliths, Acheuilian, France. C. Neolith, Denmark. (A, B, C after MacCurdy from Osborn; 1, 2 after de Mortillet from Hoernes)

treats. During the first two of these ice advances and their included interglacial period, man was in the Eolithic stage of culture. And thus it was not until the middle Pleistocene that the existence of Paleolithic man is first recognized.*

The finding of certain human skulls in the upper Pleistocene finally established the former existence in Europe of another human type so different from both Eolithic and modern man as to be considered a distinct species. This is the Neanderthal man, or Homo primigenius (Figs. 3, 4). Perhaps the two most famous specimens of this type are the Neanderthal man and the man of Spy. The former consists of a human skull, associated with no implements, which was found in 1856 in a cavern near Düsseldorf, Germany. Its stratigraphic position and hence its geological age were somewhat doubtful. Later finds, however, in stratigraphically well assured position showed the same primitive characters as this Neanderthal skull and accordingly it has given its name to the type it represents. At Spy, near Namur in Belgium, two skeletons were found associated with the remains of the mammoth and with implements of a certain type, the Mousterian. Many other skulls and a few more or less complete skeletons found especially in caves of France and Belgium combine in giving us some conception of the appearance and capabilities of this Neanderthal man; the

* Except for his implements there are no undoubted remains of man from the Mesvinian to the Acheuilian inclusive.



A Comparison of Jaws. Figure 2—A. Articular condyle to hinge jaw to skull (in glenoid fossa); at its anterior edge are attached the muscles (external pterygoid) mainly responsible for moving the jaw forward and sidewise. C. The process (coronoid) for the attachment of one of the muscles (temporal) which brings the lower jaw with force up against the upper; the other muscles aiding this are the masseter (attached to the angle (a) and ascending branch) and the internal pterygoid (attached to the angle (a)). S. The sigmoid notch at the top of the ascending branch of the jaw grows deeper as the jaw becomes lighter. c. The canine tooth projects above the level of the other teeth in the anthropoid and is also separated from the first premolar (p) by a gap (diastema). This latter may have been true in the Sussex man. 1, 2, 3, first, second, and third molar teeth. The Sussex jaw (Eoanthropus dawsoni) has been restored from the broken line (X) to the tip of the jaw (after Lankester in the *London Daily Telegraph*)

From left to right the jaws are,—(upper row) Heidelberg man, Chimpanzee; (lower row) modern man, Sussex man.

various weapons and tools found associated with these remains indicate something of his state of culture and manner of life, and the remains of animals in these same deposits enable us to understand the climatic conditions to which he was subject.

The skull is especially remarkable in its very low, flattened forehead and long backward extension, in the very prominent eye-brow ridges joined over the nose, and the large eye cavities and nasal opening, in the retreating chin and in the massive character of the lower jaw (Figs. 3, 4). The notch at the top of the ascending branch is almost as shallow as that of the Heidelberg jaw.

Such an extremely low forehead leaves little room for that part of the brain which is associated with higher mentality, such as the power of association of ideas. Hence we may assume this man as possessed of little power of memory and inference and perhaps without much capability of articulate speech. The large space at the back of the skull for the lodgment of the optic lobes should indicate a well-developed power of observation. The limb bones are massive, with the thighs (Fig. 5) and upper shin bones curved, suggesting the peculiar gait supposed to have been characteristic of the Neanderthal, that is, a somewhat stoop-

A B

Figure 3—A. A skull of the Neanderthal man (Homo primigenius) from Le Moustier, France. B. Skull of a native Australian. These agree in the very slight forehead, strong eye brow ridges uniting across the nose, face strongly prognathous, wisdom tooth largest of the molars (in Europeans it is the smallest or wanting entirely), principal chewing muscle (temporal) very large as is shown by the strongly impressed area for its attachment from the strong temporal ridge (X) down to the coronoid process (C). The brain of the former was the larger. Sollas (in "Ancient Hunters") looks upon the Australians as the degenerate descendants of the Neanderthal race, though somewhat mixed with other blood. (A, after Hauser, from MacCurdy; B, after Klaatsch from Buttel-Reepen)

ing gait with the knee joint not straightening completely at each step. His height was about five feet, three inches.

Nearly all of the skeletal remains of Homo primigenius are found in association with one type of weapons and implements, named the Mousterian from its abundant occurrence at Le Moustier Cavern in southern France. Two typical implements of this type are the side-scraper and the Moustier point. This side scraper is especially characteristic of the Moustier industry, chipped on one face only and with a curved scraping edge, opposite which is generally left part of the original surface of the flint to serve as a grip.

It is supposed that through the long ages man gradually evolved this implement from the eolith. Several transitional types are recognized and named—the fact that they are transitions being shown by their form and workmanship and in many cases by their intermediate stratigraphic position. This evolution is well displayed for example in the famous site of St. Acheuil, a suburb of Amiens, France. Pits dug in deposits of clay and gravel along the river disclosed a succession of strata containing a succession of implements from Eolithic types up through the Paleolithic and into the Neolithic. Thus the lower gravels contain the coarsely flaked type of implement to which the term Chellean has been applied, the middle gravels contain Acheuilian, more finely flaked implements, and the upper gravels and brick earth, Mousterian types grading up into Neolithic implements.

In some other localities a Strepyan stage has been recognized which still earlier than the Chellean showed the deliberate flaking for the making of a weapon which characterizes the first Paleolithic weapons in contradistinction to the eolith, which man used as a weapon either just as he found it or with at most some slight chipping off of inconvenient angles.

Our knowledge of the climate of central Europe during Paleolithic time and of the environment against which these early men struggled and to which they had to adapt themselves is based largely on the remains of animals found in association with these human remains and implements. Thus we know the Chelles period of the early Paleolithic was a time of warmth. Man probably lived in some part at least upon wild fruits and roots and likewise hunted various small animals as well as the mighty straight tusked elephants (Elephas antiquus) and the broad nosed rhinoceros (Rhinoceros mercki) which during the middle Pleistocene roamed over central Europe. As man possessed no very efficient hunting weapons at this time, he probably captured these huge animals by means of pitfalls.

The fauna of this stage as a whole is that of forests, river borders, and open meadows.

The warm climate of the Chelles period is further evidenced by the plants found in these mid-Pleistocene strata. Figs and the sweet bay flourished and a species of ash now found in Italy and Corsica.

To the many centuries of the Chelles period there gradually succeeded a colder climate. The animal and plant forms of the warm forests either died off or migrated into other regions and their place came to be taken by the life of grassy, treeless steppes. Man's implements at this time have developed into what is known as the Acheuilean type. They are more carefully and sharply pointed than the Chellean and more finely chipped. (Figs. 1, 1 and 2.) The colder climate of this Acheuilean epoch finally culminated in the glacial conditions of the Mousterian epoch, a term again introduced from finds in a cave in France. The grassy steppes have become impoverished mossy plains or tundras, the straight tusked elephant (E. antiquus) is no longer found north of Italy and the broad-nosed rhinoceros has likewise disappeared. The number of food plants grows less and less and man lives more and more by the hunt—upon the wild horses of the steppes, the mammoth (Elephus primigenius) (Fig. 6.) and the reindeer. The fact that man at this time lived largely in caves and rock shelters is another indication of the cold climate.

Slowly man learned to carve the bones, teeth and horns into implements of use and beauty. In the Mousterian for the first we find pointed implements for boring holes. To this epoch belong most of the skeletal remains of the Neanderthal man thus far found. Many caves, especially in France and Belgium, have yielded such remains, either as skulls or at times as several more or less complete skeletons. In the cave of Le Moustier in France the body had been laid in a position of ceremonial burial with his head resting on a flint plate of careful workmanship. Other conditions are shown by the skeletons found in the pit of Krapina in Croatia—a pit now filled with glacial sands but which was once in the bed of a brook now many feet deeper. The remains were of about ten individuals of different ages and the shattered and burned condition of the bones is held to indicate that they are the relics of a cannibal feast.

The Mousterian, according to Penck corresponds to the third glacial advance, the most extensive ice invasion known; to it after a short interglacial period succeeded the fourth and last great glaciation of the old and new worlds, including in its advance, maximum and recession the three last stages of Paleolithic culture. This upper Pleistocene time is the period of the reindeer (R. tarandus), of the giant woolly rhinoceros (Rhinoceros tichorhinus) and of the arctic, woolly mammoth (Elephus primigenius); the musk ox (Ovibos moschatus) returns and there are large herds of reindeer, driven south by the advance of the ice sheet over northern and central Europe, the reindeer penetrating even as far south as Spain. The name of tundra fauna has been given to the fauna of the time of greatest glaciation, characterized by the musk ox, reindeer, arctic hare and arctic fox, etc. It has been definitely proved by the geologic deposits at several different points that this fauna was followed by a steppe fauna. The reindeer, rhinoceros and bison roamed freely, wild cattle (Bos

A B

Figure 4—A. The La Chapelle man, a primitive representative of the Neanderthal race, compared with B, a European. Note in the latter the prominent forehead, nose and chin, the weak eye brow ridges and teeth, and the lighter build of the lower jaw. (A, after Boule from Buttel-Reepen; B, after Buttel-Reepen)

primigenius), wild horses (close kin to the existing E. przwalskii of Russia), and antelopes, grazed on the plains. Certain drawings on the walls of caves inhabited by upper Paleolithic (Magdalenian) men depict this horse of the steppes. Such animals are still found in the steppe regions of northern Asia.

The culture stage succeeding the Mousterian is termed the Aurignac from a locality of implements in southern France. The characteristic implements are points and scrapers of chipped flint with which wood and bone would be worked, bone needles and spear points, often forked at one end for the attachment of a haft. To this period likewise belong the first truly artistic attempts. Tiny human figures are carved out of ivory or stone, and the paintings on the walls of some caves belong probably to this epoch also.

Next succeeded the Solutrean; this stage of culture is typically represented at Solutré in eastern France, where was a Paleolithic open-air camp. Fragments of about 100,000 horses, mingled with the bones of other animals of the chase formed a sort of rampart around this camp. This was the forest type of horse, a short-limbed pony, with teeth and hoofs adapted to life on the low-lying ground in the vicinity of forests. There is no evidence that man reared these animals for food or other use. This was the acme of the Paleolithic working of flint, characterized by finely chipped lance heads, mostly of laurel leaf shape and with a notch for the attachment of a haft. Sketches were made on reindeer horns and bas reliefs were carved from them. Of course it is probable that mammoth ivory and reindeer horn, the bones and teeth of animals and bits of stone were not the only materials that man carved and adorned with his flint knives. But such other materials as wood have not been preserved.

The Paleolithic closed with the Magdalenian—so named from the cave of La Madeleine in Dordogne—the period of the last glacial retreat. The fauna takes on a more and more modern aspect until at its close we find practically no more remains of entirely extinct animals. That the climate was still cold is indicated by the figure of a glutton carved on a bit of bone from a Dordogne cave and by the remains of some northern varieties of moss. Reindeer antlers are carved with engravings of various animals. Flat stones are painted with red and black simple designs of points and lines; tiny human figures are carved out of ivory. Sketches of the mammoth, the horse, the bison and the Saiga antelope adorn the walls of caves of this period. Birds are

represented by the swan and the wild goose, fishes by trout, pike and salmon.

Wall sketches (Fig. 6.) have already been found in twenty-seven caves of southern France and northern Spain. It has been suggested that the fact that nearly all of the animals pictured were useful to these hunter and fisher folk may be explained as the use of a sort of magic. It is a common primitive idea that the possession of a picture gives power over the object pictured and thus would make easier the capture of food animals.

Though Homo primigenius, the Neanderthal man, is the human type specially characteristic of the lower Paleolithic, skeletal remains in certain cave deposits indicate that at first contemporary with him and gradually displacing him in the upper Paleolithic lived another type of man so different as to constitute another species.

This type, far more advanced than Neanderthal man, is Homo sapiens, the species of modern man. Specimens of this type in this remote Paleolithic time, display the modern characteristics of high, vertical forehead, reduced eyebrow ridges and projecting chin though naturally to a less advanced degree than in the modern European. Several types of this advanced species have been found in the cave deposits of Europe. Among them are a supposed Negroid race, the Grimaldi, and a tall, stalwart race, the Cro-Magnon, with an average height of at least six feet.

The cave of Cro-Magnon is in a limestone cliff overlooking the valley of the Vezere near Dordogne. It was discovered in 1868 and in it the skeletons of two men and a woman; with the human remains were found worked antlers of the reindeer and remains of the horse, mammoth, cave lion and cave bear. A few other Paleolithic cave finds in France reveal the same type of skull and indicate remains of this same Cro-Magnon race. These finds are mainly assigned to the Magdalenian period. The skull of these precursors of modern man is characterized by a high forehead, reduced eyebrow ridges, great cranial capacity and a slightly projecting chin.

That this superior type may have existed side by side with the Neanderthal in yet earlier Paleolithic times is indicated by the Galley Hill specimen, found in ancient river gravel near Northfleet in Kent in association with implements of Chelles type. The skull has a comparatively high, convex forehead with eyebrow ridges not exaggerated. It is considered as representing a superior race, quite distinct from the Neanderthal, which existed even in these early Paleolithic times and developed into the Cro-Magnon type of the later Paleolithic.

An even earlier beginning of this superior race may possibly be shown in the finding in 1911 of a skeleton of this type in Ipswich, England; the glacial deposits in which it was found are provisionally assigned to the Mesvinian, the latest Eolithic horizon.

One of the more interesting of the theories proposed to account for the existence of these two distinct species side by side in the Paleolithic is that man had a diphyletic origin. According to this hypothesis of Professor Klaatsch, the Neanderthal man and the African anthropoid apes, the gorilla and the chimpanzee, diverged in the far distant past from a common ancestor and on the other hand, the upper Paleolithic and recent man is more nearly allied to the Orang-utang, springing from a common ancestor with this Asiatic anthropoid. According to this theory, the more primitive Neanderthal man first entered Europe from Africa, while a later invasion from Asia introduced the higher Homo sapiens.

However the origin of the two types be accounted for, the beginning of the Neolithic or possibly the upper Paleolithic must have found the Neanderthal man either extinct or at least vanished from Europe.

Neolithic

As the great glacier invasion slowly retreated north and northern Europe became depressed, the climate became more humid and reforestation set in—thus began the era of modern forest-dwelling animals and of Neolithic man.

Enormous intervals of time must have been consumed in this successive peopling of central Europe by the fauna of the tundra, of the steppe, and of the forest. Only slowly were the steppe mammals driven by the increasingly damp climate toward the east to make room for the forests and their fauna. It has been shown that the large herbivorous animals, because more closely bound to their special environment were the principal migrants. Carnivores could more often continue from one climatic period into the next. The horse, likewise, continued through steppe times into the forest period, through the migration of special types fitted to these habitats—thus we can distinguish steppe and forest types of horses. The reindeer also was found in the forests of Germany after the time of Caesar. But in general the country of Neolithic man was filled with a changed fauna, which included the common squirrel, red deer, moose, red fox, wild boar and brown bear. This Neolithic fauna is the direct descendant of preceding faunas; no new mammals except those introduced by man appear from other regions to take the place of the now extinct mammoth, woolly rhinoceros, cave bear and cave lion and the highly specialized tundra and steppe types which have been forced to retreat to the north and northeast.

We find at the dawn of Neolithic civilization in Western Europe a primitive people living largely on shellfish, as well as the produce of the chase, and fruits, roots, etc. They probably were somewhat assembled into communities but they had at this time only rude implements of stone, bone and horn. It is supposed that the dog was domesticated about this time by the Neolithic men of the Danish kitchen middens.

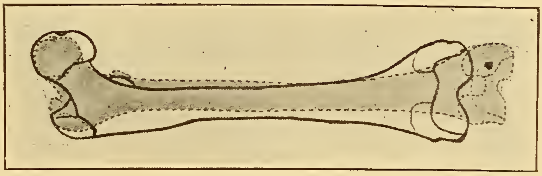


Figure 5—Thigh bone of a Neanderthal man (in outline) compared with that of modern man (shaded). The ends of the former are larger, giving big clumsy joints at knee and hip; the shaft has a marked bend forwards in the middle, so that he could not completely straighten his legs at the knee-joint but always kept them slightly bent in walking or standing. The shaft, likewise, is much wider from side to side than from before backwards while that of modern man is almost a perfect cylinder (after Keith)

In certain caves of western Europe the remains of the Paleolithic and Neolithic periods are separated by layers of stalagmite which must have taken an immense period of time to form. Certain other settlements show by their cultural remains uninterrupted habitation from Paleolithic into Neolithic times. It has been suggested that while some of the old settlements of Paleolithic time were abandoned and whole communities followed the retreating reindeer to the north, a part of the ancient population still lived on in western Europe, finally amalgamating with new comers who in a constant stream of immigration brought a new culture from the east. On this theory the two industries of ivory and bone working and of the flaking of flint for a time existed side by side, and while the flint industry developed new forms in the Neolithic times, the working of ivory and bone gradually died out with the disappearance of the mammoth and reindeer. At any rate it is supposed that a new culture from the east gave European Neolithic man the art of polishing stone and of geometric ornament. Wheat, barley and millet were introduced from the Orient and agriculture became more and more important. The people became less nomadic, living mostly in villages of half underground huts,—a type of habitation that spread all over Europe and persisted for centuries.

This epoch was preëminently influenced by the domestication of animals. The successor of Paleolithic man possessed the sheep, goat, hog and ox as well as the dog. He captured and domesticated at least three indigenous European

species, the forest horse (Equus caballus typicus) and the Celtic pony, a plateau type (E. caballus celticus), and the Celtic short horn cattle (Bos longifrons). He hunted the wild ox (Bos primigenius), the urus of Caesar which survived in Germany until the twelfth century. His domestic ox (Bos taurus) is descended from an Italian Pleistocene form and hence was probably an inheritance from the east along with the sheep, goat and hog.

The wonderful skill of the cave men in delineating animals was not handed on to the new stone age but the principal attention was given to the flaking and polishing of flint implements. The methods adopted by Neolithic man for extracting flint are illustrated in several ancient flint mines in England. These early miners excavated shafts in the chalk rock to depths of ten to forty feet and from the bottom of the shafts tunneled galleries following the seams of flint. The implements they used in this work were picks of red-deer antlers and rude flint tools. Some of the galleries are nearly thirty feet long. Hence they were probably artificially lighted—perhaps cups cut out of chalk such as have been found in some of the mines served as these primitive lamps. Such mines exist in Norfolk and Sussex in England and in Mons, Belgium.

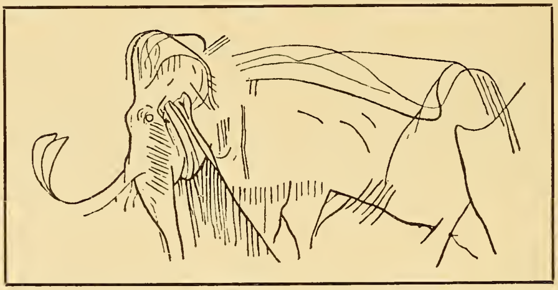


Figure 6—The hairy mammoth (Elephas primigenius) engraved on ivory, from the rock shelter, La Madeleine, France. It belongs to the Magdalenian culture epoch. It faithfully portrays all the striking characteristics so well known to us now through the well-preserved animals from the frozen soil of Siberia; the profile of the head, curving tusks, small eye, large mouth and long hair are all shown (after Lartep and Christy from Sollas)

The earlier lake dwellings and kitchen middens of Europe are of this period.

It is probable that man's appearance has changed very little from Neolithic times to the present. (Fig. 9.) The teeth of Neolithic people are usually much better preserved and more regularly placed than in modern man. It has been suggested that the method of mastication has altered, since in Neolithic man the incisor teeth at rest meet edge to edge, allowing a freer sidewise grinding movement and a more regular wearing down of the crowns. One other skeletal difference is the flattening of the shin bone (tibia) in contrast to its prismatic section in modern races,—a feature possibly connected with changes in posture and gait.

But in stature and form of head, specimens of the Neolithic men of England are nearly or quite like some types of modern Englishmen. Yet such a specimen, the Tilbury man, for example, was found in the Thames valley beneath 31 feet of strata, thus showing the presence of this modern-appearing Neolithic man when the river flowed in a channel more than 30 feet below its present level. Such an extended interval of time,—variously estimated at from 15,000 to 30,000 years,—as would be consumed in bringing about this change in the Thames valley, indicates the extreme slowness with which man's physical characters have changed.

Estimates of Time

There have been various estimates of the time in years that was consumed by this slow evolution of man's physical form and intellectual powers. Estimates of the length of the Glacial period vary greatly. For example the climax of the fourth or great glacial advance is placed by various students of the Pleistocene at from 20,000 to 60,000 years ago. The length of the entire Glacial period (Pleistocene) is estimated as 100,000 years

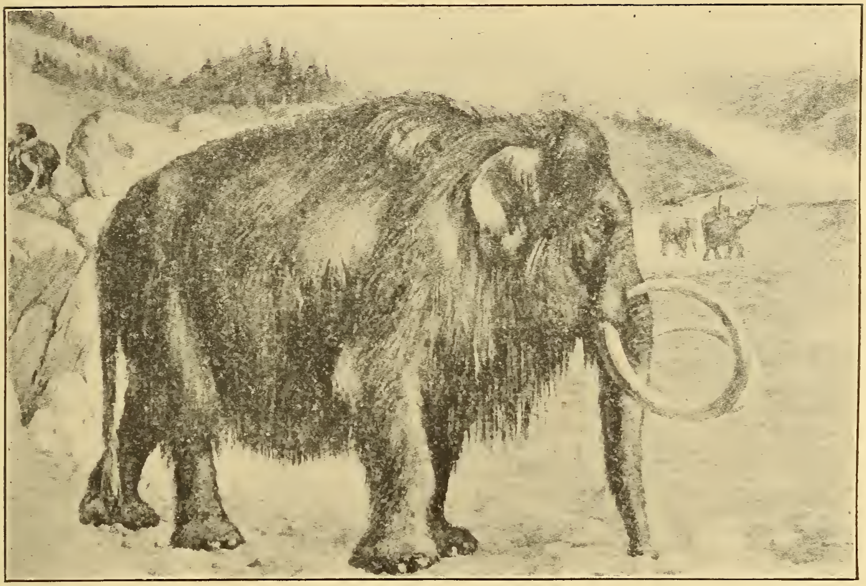


Figure 7—A painting of the hairy Mammoth by Knight (from Osborn)

by Upham, 400,000 by Sollas, and 500,000 to 1,500,000 by Fairchild; while Penck believes that the whole Ice Age lasted somewhere between 500,000 and 1,000,000 years and he reckons that 30,000 to 50,000 years have elapsed since the climax of the last glaciation. So according to Penck the last of the Paleolithic period was perhaps 16,000 years ago, while the man of Heidelberg lived 500,000 or perhaps a million years ago.*

Compared with the length of the Paleolithic, the Neolithic and the later metal periods are of insignificant length for it is estimated that the beginning of the age of metals dates back three thousand to three thousand five hundred years in central Europe.†

* The following are some of the modes of estimating geologic time;—(1) Comparison of present rate of accumulation of sand and mud on a delta, etc., with the total thickness of such rocks. (2) Comparison of the present rate of the wearing away of land with the total amount of such erosion in the past. (3) Comparison of the rates at which present glaciers move forward and retreat, with the total amount of such movement in the past. (4) Chemical content of the sea. (5) Astronomical changes. One method of estimating mode (2) is the "cedar-root chronology" evidently invented by James Hall in estimating that a certain mastodon (of late Pleistocene Age) in New York State was deposited by the stream at least 35,000 years ago. Knight used this method in working out the time necessary to erode a vast depression in Wyoming, known as Bates-Hole. Many pine trees grow upon its slopes; these have the ground removed from their roots to an average depth of three feet. By cutting down some of the trees and counting the number of concentric rings (a ring to a year) it was found that they had an average age of 300 years. Hence one foot was eroded in 100 years. Three miles have been eroded; but before erosion began Miocene beds had been deposited, hence erosion did not begin before the beginning of the Pliocene. So according to this estimate, 1,584,000 years have elapsed since the beginning of the Pliocene time. One method of estimating mode (1) is that of de Geer, who, maintaining that the greater melting of the glacier front during summer would produce a layer of mud over the land before it, has counted 5000 such layers in Sweden; making thus the time occupied by the retreat of the last glaciers over Sweden alone 5000 years.

†The beginning of Egyptian civilization is usually placed near the beginning of the Neolithic period; but this as well as those of Assyria and Babylonia had reached the Iron period while Central and Northern Europe was still in the Neolithic.

In North and South America most conservative geologists hesitate to assign man's earliest presence on these continents before the close of the Glacial period.

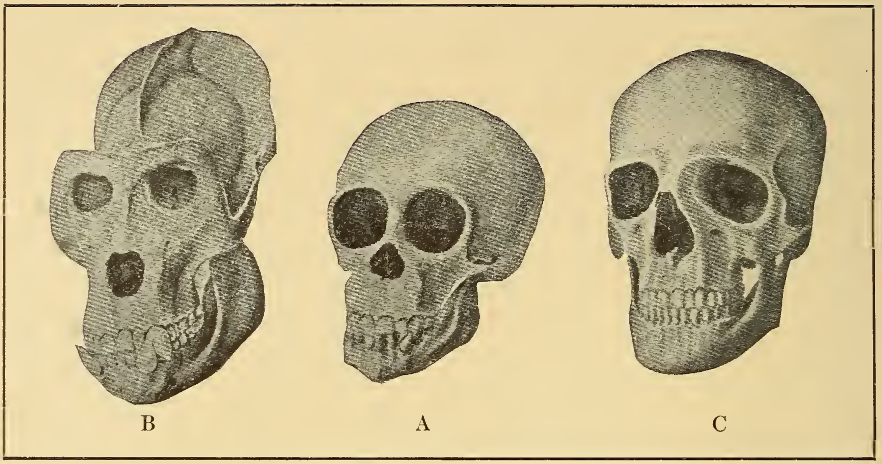


Figure 8—Comparison of the skulls of the young gorilla (A) with the adult gorilla (B) and adult European man (C). Compared with the adult man (C), the skull of the adult gorilla, (B), (as well as the other anthropoids) shows degeneracy from that of its own youth (A) in the reduced forehead, the greatly increased massiveness of the lower jaw, the wonderful reduction of the chin and in the great development of the eye-teeth. The heavy ridges (sagittal and lambdoidal crests) projecting upward and outward from the skull of the adult gorilla are associated with the greater development of the temporal muscle in closing the jaws; they are absent in the female (from Buttel-Reepen)

Comparison with Living Races

We find living in the world today all stages of culture from the Eolithic Semang of the Malay peninsula with apparently only such stone implements as they chance to pick up, through the very primitive Paleolithic of the but recently extinct Tasmanian aborigines, with knives chipped on one side only, and the higher Paleolithic of the Australian aboriginees,* the Veddahs of Ceylon, south African Bushmen,† Tierra del Fuegans and Esquimaux,‡ through the Neolithic culture of the natives of New Caledonia to the highest types of modern material advance. This complexity may on the one hand be explained on the same line as the present complexity of organic types; for example bivalve shells first appear in the lower Paleozoic, fish in the middle, and reptiles in the upper Paleozoic, but all continue living to the present; the higher type does not destroy the lower.* So the Eolithic culture may have appeared first, next the Paleolithic and

* See figure 3 B.

† Sollas, in "Ancient Hunters," suggests that these Bushmen are the present day representatives of the Paleolithic Aurignacians. Their skulls closely resemble each other in all respects and they similarly inhabit caves whose walls they very artistically decorate with monochrome and polychrome paintings. They likewise throw their kitchen waste in heaps,—at one place the Bushmen had thrown several hundred skulls of gnus in a single heap, as at Solutré paleolithic man had similarly collected the bones of the horse into a heap over 300 feet long by 10 feet high. Evidences of Bushmen are found over much of South Africa though at present they inhabit only the Kalahari desert.

‡ Sollas, in "Ancient Hunters," suggests that the present day Esquimaux are the direct descendants of those Paleolithic Magdalenians represented by the Chancelade skeleton. They are both of short stature, are orthognathous and indeed similar in every feature of the skull, including the peculiar keel-like appearance (from front to back) of the top of the skull. They are similar in their culture; both are most artistic in sculpturing figures in the round. It is suggested that as the reindeer followed the melting glaciers northwards the Magdalenian race followed their chief source of food;—the reindeer, probably by way of northern Asia (since the old land-bridge by way of Iceland had broken down in the Miocene or Pliocene). Magdalenian man, a hunter, was probably urged in his northward migration by the spread of Neolithic man, a farmer. Agricultural people are always more numerous than hunters; since about a thousand of the former can subsist on the same amount of land as one of the latter, hunters must always give way to the superior numbers.

*See figure 12.

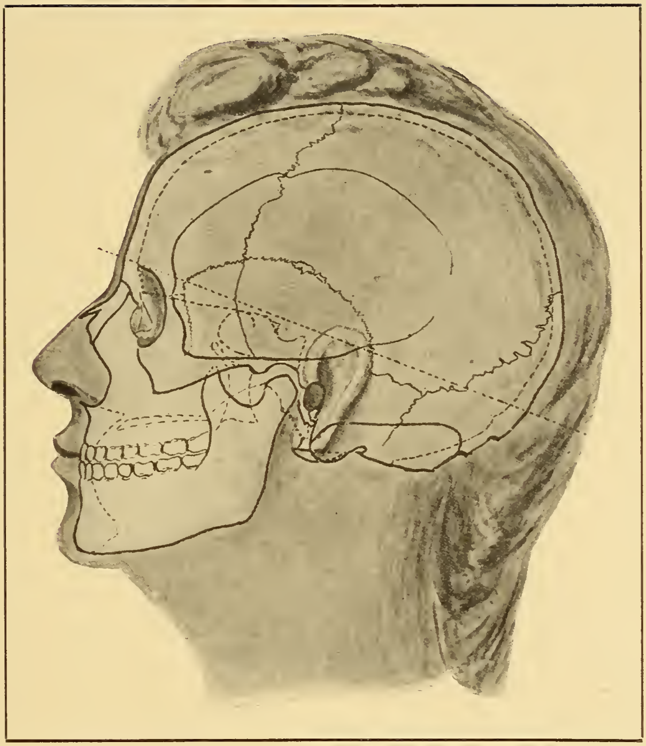


Figure 9—A late Neolithic skull (the Essex woman) from the east coast of Essex, England. The relation of the soft to the hard parts is indicated. Note on the skull the the high forehead, long bridge of nose and slightly projecting chin (after Keith).

finally the Neolithic; but the lower cultures continue to exist in remote regions.* On the other hand, there is strong evidence in fossil remains, language, etc., that many of the primitive peoples have degenerated from a higher civilization. The evidence at present, however, apparently indicates that in Europe, at least, there occurred a development from the Eolithic, successively through the Paleolithic, Neolithic, bronze and iron culture periods. Thus in Europe undoubted eoliths are recognized from the Pliocene and lower Pleistocene, paleoliths from the middle and upper Pleistocene and neoliths from its close. The skeletal remains of man point to a similar conclusion; the most primitive type with the very heavy jaw, chin strongly retreating, and retreating forehead occurs only in the lower Pleistocene; with the mid-glacial times a higher type occurs—the low-browed Neanderthal race. Thus according to the cultural and skeletal evidence now at hand the modern European man has developed from a primitive type approaching the existing higher apes in physical characters; and it should be remembered that among living races it is those with the lowest degree of culture, as the Veddahs of Ceylon and the Australians, who possess the most ape-like physical characters.

Comparison with the Anthropoids

It is the belief of most workers along this line that modern man and the modern higher apes or anthropoids (Chimpanzee,

* "Many of the savage races still surviving are merely side eddies of an earlier stream of culture through which civilized races have passed." Robert Munro, "Paleolithic Men." p. 24. (See figure 13.)

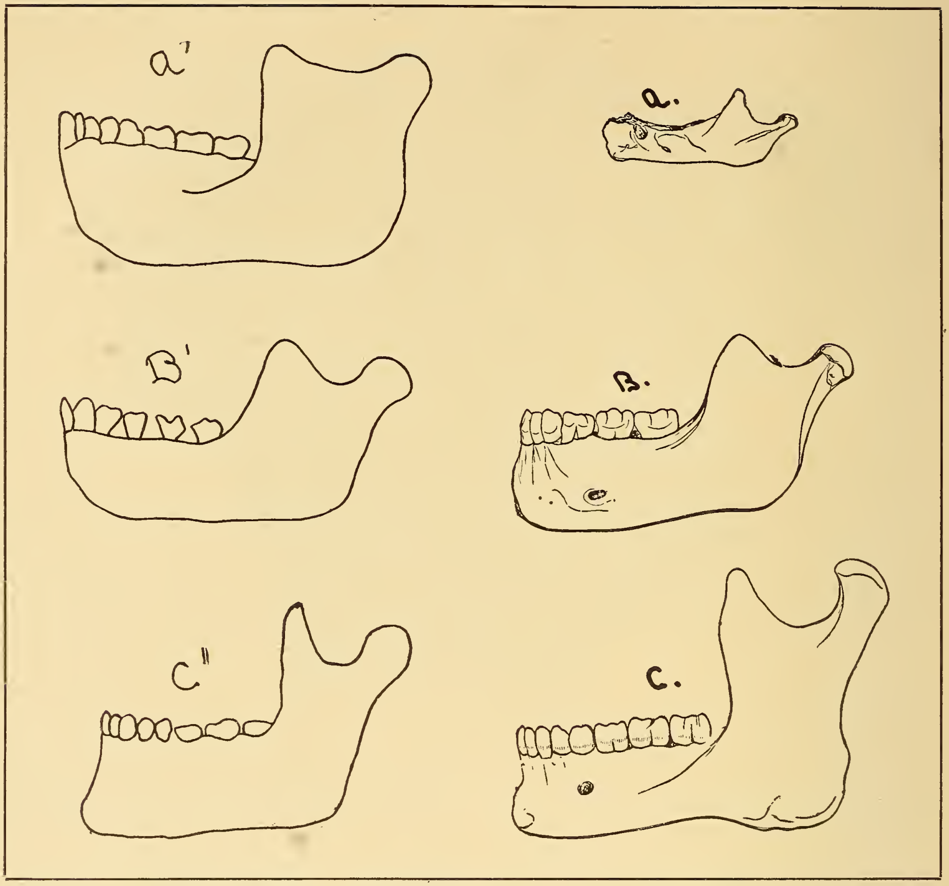


Figure 10—A series of the modern European jaws from birth through adolescence to adulthood compared with a series of adult jaws of early man. At birth (A) the jaw is similar to that of the adult Eolithic man (A′, Homo Heidelbergensis) in its strongly retreating chin and broad ascending branch with a shallow notch at its top. At adolescence (B) the jaw has become like that of the full grown lower Paleolithic (Neanderthal) man (B′, LeMoustier man) in its almost vertical chin and its still broad ascending branch with the shallow notch. At adulthood (C) it is similar to the jaw of Neolithic man (C′, Essex man) in its projecting chin and its narrow ascending branch with the deep notch at its top. For these features in a later man (see Fig. 4, B) (A, B, C, from Gray's Anatomy; A′, B′, C′, tracings; A′, reduced after Schötensack and MacCurdy; B′, after Hauser's Le Moustier skull; C′, after Keith's skull of the Essex woman)

Gorilla, Orang-Utang and Gibbon) have diverged from some common ancestor, or ancestors. If this is true we should then expect to find certain resemblances between them and especially should these resemblances be more marked in the young than in the adult (Figs. 8, 11).

To mention but a few of these similarities—the young anthropoid's skull has a more distinct forehead than the adult, indicating thus a degeneration in the latter; the brain convolutions of the child are much simpler than the adult, approaching that of the anthropoid; so likewise the child's nose and more especially that of the foetus is short and broad like the ape's but with age the bony bridge of the human nose grows higher and longer. The milk teeth are more like those of the young anthropoid than are the permanent set; this is shown in the relatively higher and broader crowns of

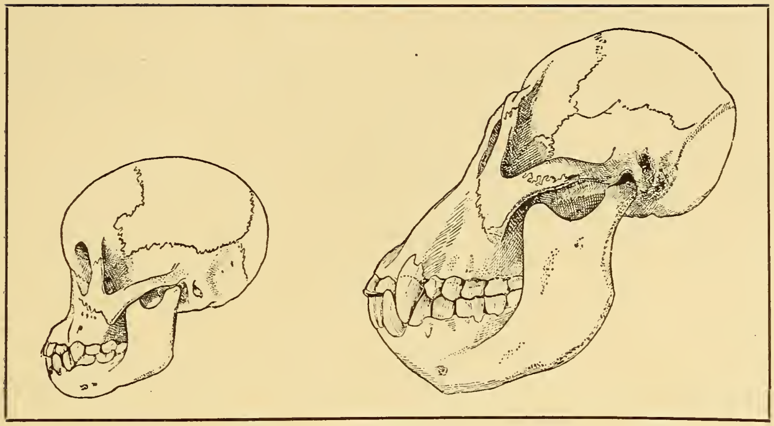


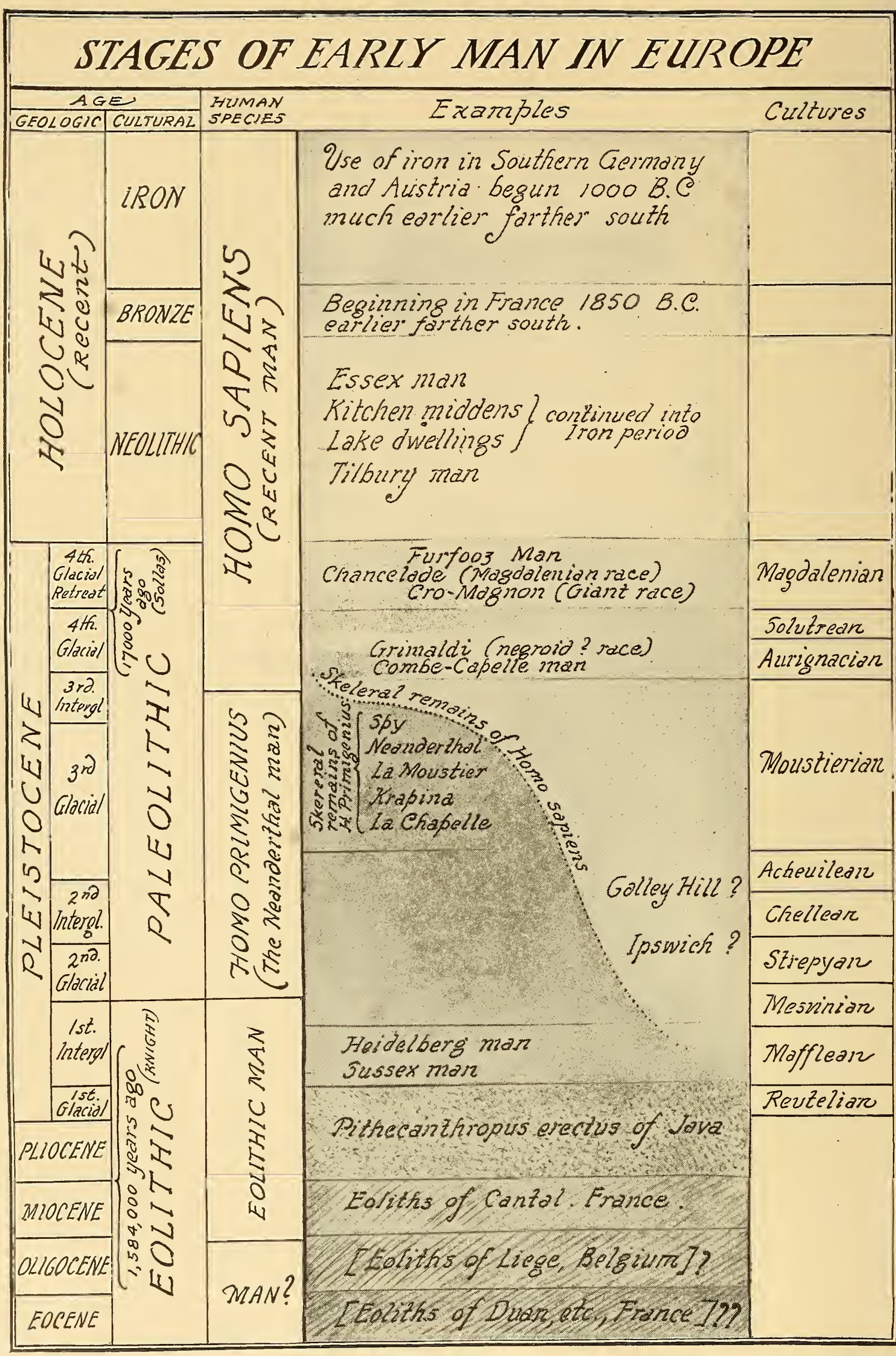
Figure 11—Compared with man the adult Orang-Utang shows degeneracy from its own youth in its reduced forehead, greatly increased massiveness of the lower jaw, reduction of chin and enlarged eye teeth. Both one third natural size (after Wiedersheim)

the molars and in the back molars being as large or larger than the anterior ones; from this rather close agreement they diverge into the permanent sets, in the anthropoids in the fang-like development of the canines especially, and in man in the degeneration of the back molars, the third or wisdom teeth being in the Aryan races small crowned and often wanting. The arm of the anthropoid is relatively longer than that of man; this is chiefly due to the great length of the forearm (radius and ulna) and occurs likewise in the human foetus and child. In the foot the great toe of the anthropoid stands at the same angle as the thumb on the hand and is smaller than the other toes; this is similarly true of the two-months old human foetus.

Thus in the case of the forehead, the teeth, etc., the young of the ape and man diverge strongly into the very different adult conditions.

Studies in evolution have shown that each individual animal and plant in its development from the egg or seed to maturity passes through successive stages and that these stages are similar to some of the adult stages of its successive ancestors from earliest geologic ages to the present. Illustrating this by but one example in man; we note that the lower jaw (Fig. 10) has at birth a strongly receding chin and a broad, short ascending branch with a shallow notch at top; at adolescence the chin is approximately vertical and the ascending branch is still short and broad with the notch at its top shallow; in the adult the chin projects forward, the ascending branch is long and narrow with its upper edge indented by a very deep notch; these three stages repeat almost exactly the types of jaw seen in Eolithic man, lower Paleolithic (Neanderthal), and recent man respectively. This suggests somewhat strongly that the Neanderthal and the Eolithic types of man are true ancestral stages of modern man.

Thus the most prominent features of man's physical evolution from the beginning of the Pleistocene to the present are seen to be the increase in prominence of the front cerebral portion of the brain case, producing a more and more upright forehead, the increase in the prominence of the chin and the parallel decrease in prominence of the upper jaw. Thus from a prognathous type, in which the retreating forehead and chin leave the tooth-bearing portion of the jaws projecting and prominent, has developed the modern orthognathous type in which the upper and lower parts of the face have come into



This table gives a few of the principal finds of human remains, correlated with the geologic periods in which they occur, and with the type of implement with which they are associated. The widening spaee represents the increasing presence of Homo sapiens or the modern type of man. The narrowing space represents the decreasing presence of Homo primigenius or the Neanderthal type of man.

prominence and the jaws have retreated into line with them.*

The reader who may wish to follow up this subject will find the following books of interest.

"Ancient Types of Man,"—Arthur Keith, 1912, 151 pp.

"Prehistoric Man,"—W. L. H. Duckworth, 1912, 156 pp.

"Kultur der Urzeit," Vol. 1, on the Stone Age,—Professor Moritz Hoernes, 1912, 146 pp.

"Aus dem Werdegang der Menschheit. Der Urmensch vor und während der Eiszeit in Europa,"—Dr. H. von Buttel-Reepen, 1911, 139 pp.

"Paleolithic Man and Terramara Settlements in Europe,"—Robert Munro, 1912, 507 pp.

"Ancient Hunters,"—W. J. Sollas, 1911, 416 pp.

* The reason for such development is suggested by Robert Munro in his "Paleolithic Man." As the faculty of reasoning was more and more brought into play through the demands made on it for inventive skill in the fashioning of weapons and tools, human intelligence and hence brain substance steadily increased and the anterior portion of the skull had to grow to accommodate this increased cerebral substance; this increased weight of the anterior part of the head, if not counterbalanced, would have disturbed the poise of the head on the spinal column. Such counterbalance was partially effected by a concurrent retrocession or contraction of the lower part of the head, especially of the jawbones. As a result, the space allotted to the teeth diminished and thus the tooth-bearing portion of the jaws receded in prominence and as the teeth assumed a more upright position in their sockets the chin must concurrently come into greater prominence.

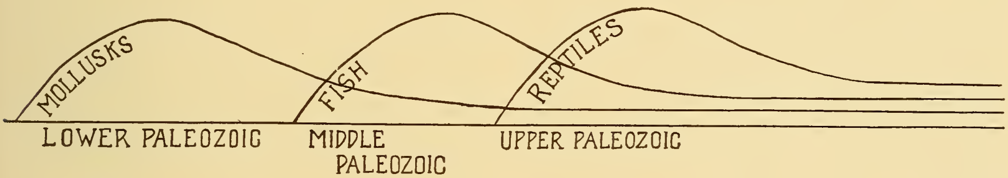


Fig. 12

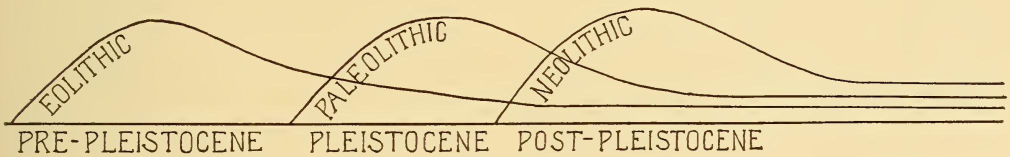


Fig. 13

Diagrams to illustrate that while in the course of geologic time more and more advanced types successfully appear yet some of the more primitive continue to exist side by side with the more advanced up to the present.

Figure 12 shows that though the mollusks, fish and reptiles arose at successive periods all continue to exist up to the present.

Figure 13 indicates the similar present persistence of the Eolithic, Paleolithic and Neolithic man and their probable similar successive appearance in the past.

CONCERNING THE CROP OF SCALLOPS

SCALLOP FARM A VARIABLE ASSET, BUT YIELDS QUICK RETURNS—COMMUNAL CULTIVATION AND TOWN COOPERATION UNDER STATE ADVICE ARE NECESSARY

BY JOHN RITCHIE, JR.

THE scallop fishery is one of the four great shellfish industries which the shore inhabitants of Massachusetts have established, the others being the oyster, the quahaug and the clam. Its importance is such that in the interests of efficiency its limitations and its possibilities should be understood, and in the interests of conservation, since it affords more nutriment than any other one of the shellfish, and since sea food is likely to play a much more important part in this country in the future than in the past, the advantages of the industry should be discussed.

From the commercial point of view the scallop has both advantages and disadvantages. The crop is one that can be secured with little delay, when the generality of shellfish is considered. There is a large ratio of the edible portion to that which must be handled in the gross; the substance is palatable; it has high fuel value and in the fishery there is practically no risk of depleting the supply by over-fishing. On the other hand, on account of the restlessness of the animal it recommends itself rather for communal cultivation than for the business undertaking of the individual. There is an interesting story along most of these lines, and these stories are popularly but little known, yet they are of importance in properly understanding the problems which beset undertaking the improvement of scallop fishing as an industry. Oysters have been fished by modern methods for years, the sand clam is coming to its true place as a Massachusetts shore industry, and to keep pace with these the problems of the scallop should be considered with intelligence and with knowledge of the facts.

The Massachusetts Fish and Game Commission should receive the credit for an investigation of the industry as well as of the other shellfisheries, and in scientific ways and utilizing trained technical men it has taken up the consideration of the problems, discussing in a commonsense way the limitations of the industry, and besides establishing its status giving hints of ways and means of setting it upon a firmer basis. In the opinion of the commission the scallop fishery is not destined to become a great industry, but at the same time it is an important one in which the methods employed have grown up without particular thought or attention as to their efficiency. It is possible to employ most recent knowledge in the work, and in doing so to arrest the decline which the industry has suffered. It can be made valuable as an aid to the gaining of a livelihood by intelligent men, and it is not without its place when the food supply of the people is considered.

The most important particular in which the scallop differs from the other familiar food mollusks is the shortness of its life. The life seems to have, however, the usual complement of shortness, for the scallop is really a merry little beast. No one can doubt this who has seen the brilliancy of its bright eyes that almost twinkle, great, blue globules, one for every convolution of the shell margin, and each valve counts in this so that the eyes are in pairs, while its graceful dance as it bobs buoyantly along beneath the surface of the water has peculiar lightness and gives to it as a living creature an interest that its rival mollusks, the mudloving clam and the bottom-seeking oyster can never hope to vie with from the popular standpoint.

The scallop is the perennial of the sea,

All the Illustrations by courtesy of Massachusetts Commissioners on Fisheries and Game.

and like the flowers to which this term is applied, the crop of next year depends directly upon the generation that is dominant today. The oysters that we eat are from the spat of some years ago, the sand clams may go on for a number of years reproducing their kind while the quahaugs have in their ranks many patriarchs who have seen the come and go of a number of years, but the scallop is an ephemeral. It has but one spawning season; it produces only the single litter of eggs, and only a small percentage of the whole species ever see a second birthday.

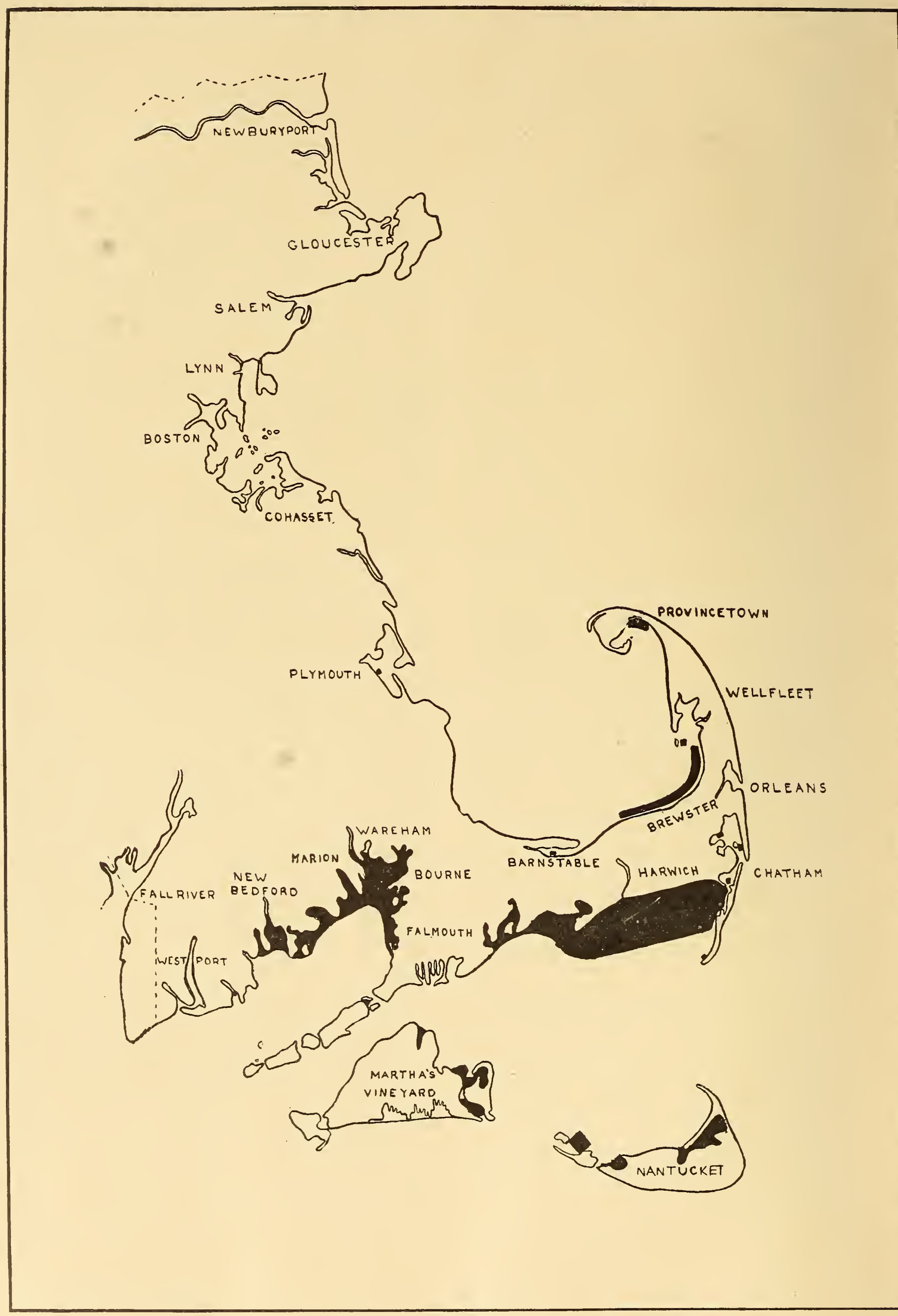
A number of important business matters hinge on this short life of the scallop. In the first place the fisherman has to wait only a year for his crop. The seed scallops of this summer will be ready for taking when the fishing begins next year, and the fisherman can take and should take every individual that comes to his dredge. He is not obliged to measure with a stick or a six-inch rule; he is not in fear of destroying his crop of next year, for if any doubt should arise he can determine whether the individual shellfish has passed its first birthday, and if it has he can take it without fear for it has laid its eggs and the next year's scallops are already growing. Just as the woodsman can tell the age of a tree by counting its rings so the scalloper can tell the age of his shellfish, only he seldom needs to count even two. For after one year, or rather the slow-growing months of the winter during which new shell accretes very slowly, there is a ring testifying to the arrested development. If the ring is there the scallop is adult, and if it is adult in October when it is taken it has contributed all that it can to the perpetuation of its race. It is rarely that the shellfish survives the second winter, so that, if not taken, it is likely to be wasted so far as the food of man is concerned.

The obverse of the shield is that, all the eggs being in one basket, if anything happens to that basket, the eggs will be lost. The whole race of scallops may be exterminated in any locality by widespread unsuitable conditions. These conditions are natural, the cold of winter, severe storms or anchor ice that drags away the scallops or the eel-grass to which they are moored. The individual scallop farmer may find his whole colony of shellfish destroyed in a season and he has no means at hand whereby to prevent this. Such facts militate against attempted cultivation in definite, separate farms, and it is this for one thing that has caused the Fish and Game Commission to suggest communal farming of scallops.

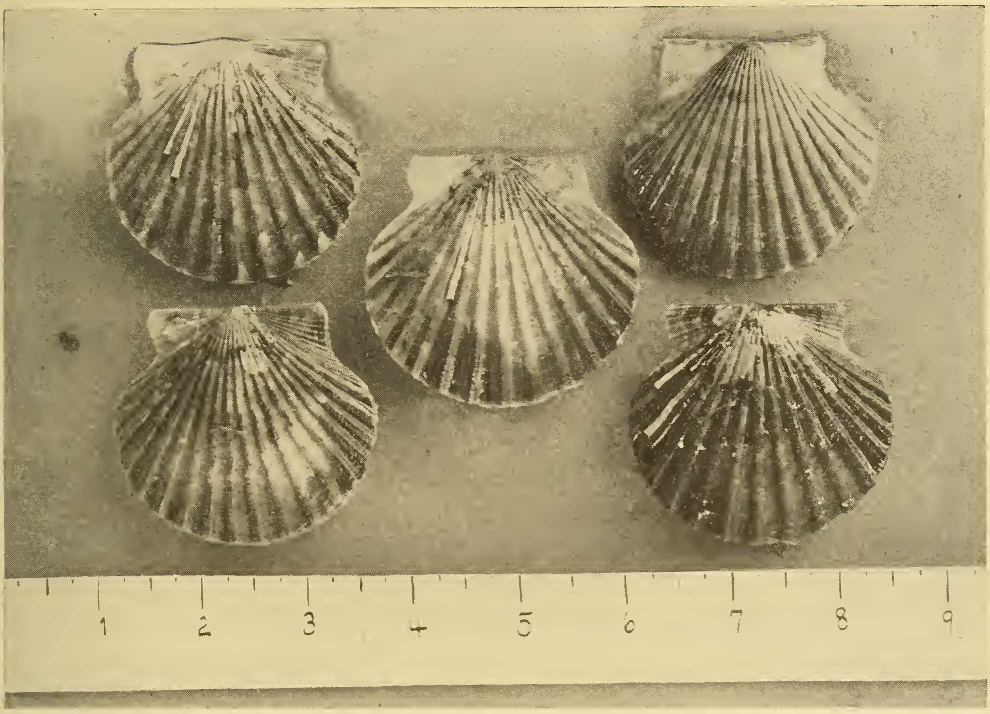
Then again the scallops are mildly migratory. The extent to which they do actually change their abodes has been magnified by that hyperbole inseparable from things marine, and they have been described as swimming away in orderly troops, seeking other shores and masters. The Massachusetts investigations have been the means of extracting the grain of truth from the mass of exaggeration.

The scallop is a free swimmer. It can maintain itself, valve-margin uppermost, in the place that suits itself with reference to the surface of the water, doing this by jets of liquid expelled by vigorously closing its valves. It has a levitation that suggests the balloon in air. In a position not vertical the impulse jumps the bivalve through the water in the direction towards which it leans. It has been determined, however, that the radius of voluntary swimming is limited, so that swimming may be regarded as a minor factor in the distribution of these creatures. Buoyancy and wave motion together, be the latter tide or storm, may clear a little sea-farm of its scallops in a single day. And the farmer can hardly depend upon any reverse of tide to bring his bivalves home.

It is such facts as these that suggest to students of the problems, such men as David L. Belding, who is the biologist of the Massachusetts Commission, that compared with the three other shellfishes, the oyster, quahaug and clam, the scallop is susceptible of much less of what may be termed cultivation. At the same time it is an industry that means part-time and part-livelihood for between six and seven hundred men, and might mean much more. Further there is employed part of a capital of $125,000, for which the annual return is about equal to the whole



Scalloping Grounds are indicated by Black Patches and Dots

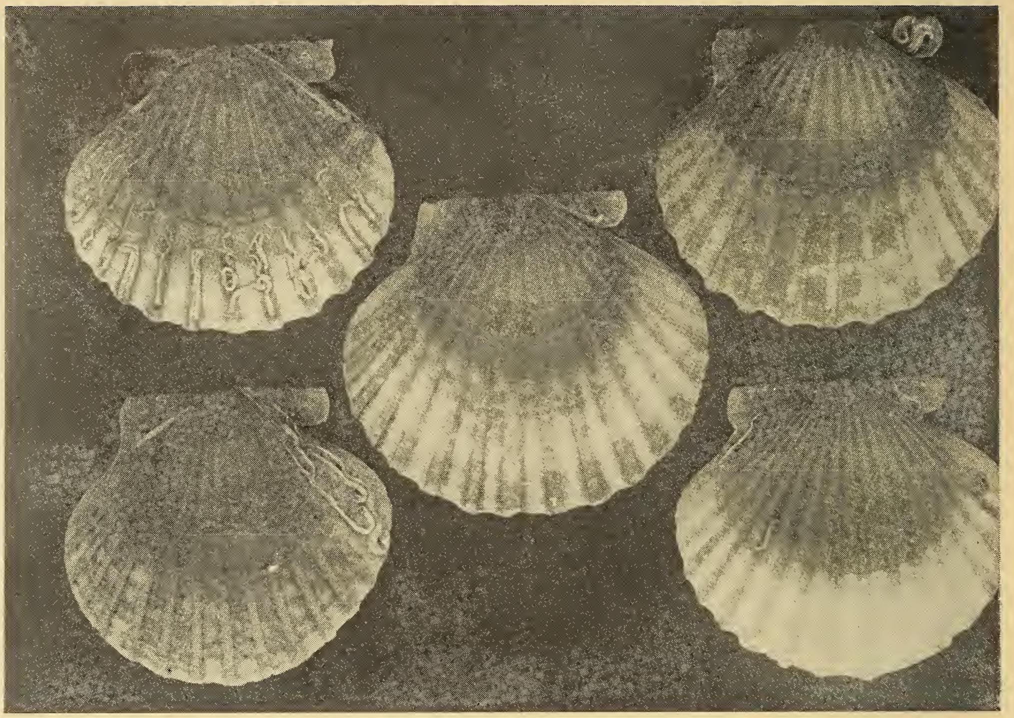


Seed Scallops, which have not yet spawned. The perpetuation of the scallops in the vicinity depends upon these and they must not be taken. They are protected by law.

capital. These figures are merely approximate since the fishery is not an independent one. Many of the same men and boats are at work part-time taking quahaugs and many of the scallops are taken on quahaug beds, so there is difficulty under the circumstances in getting precise figures.

The place of the scallop industry may perhaps be best illustrated by bringing forward the figures, so far as they have been determined. The quahaugs yield in Massachusetts about $200,000 a year, the oysters about $175,000, the clams about $150,000 and the scallops, $165,000. To get these returns there are 160 oystermen with an investment of $1,600 for each man employed; in the taking of quahaugs there are 750 men with a capital of $130 for each; the scallops give employment for a time to 650 men and the capital needed is about $150 per man, while for the clam there are double as many men employed but the capital here required is little more than the clamfork and baskets, and reaches only about ten or twelve dollars a man. One can gain from this some idea of the complication of the financial end, the relations of capital and labor, and how this varies for the different industries.

There is a further complication in the seasons during which the different industries are worked and their relations to other pursuits of the fishermen. The men engaged in one fishery may shift to another if the open seasons do not overlap. The beginning of the scallop season marks the decline of the quahaugging. In fact some legislation with reference to the former has been made in consequence of the chance to fish the latter. The quahaug is a summer shellfish while the scallop is spawning in warm weather and may be taken from October till April. The quahaug men have also a summer lull partly because the same men are required for the lucrative work induced by the summer visitor. The oysters have a winter catch, beginning in September



Adult scallops. At the edge of the dark area is the annual growth line. Absence of this line defines the molusk to be a seed scallop. These adults have spawned and few ever reach the second birthday. They can all be taken for food.

and lasting as long as the weather will permit.

When all the facts are considered they seem to justify the conclusion of the Fish and Game Commission that the scalloping industry is not likely to become a dominant one, for the scallop has the two weak links in its chain, its perennial nature and the fact that individual scallop farms are a variable asset. It is true, however, that the discovery of a method of artificial propagation of the scallop, which if successful would do away with the enormous "infant mortality" of the shellfish, might go far towards eliminating the weak places, but till today such methods are lacking.

An adult scallop—the name of the species, by the way, being Pecten irradians, which gives way under rules of priority now to P. gibbus, var borealis—when it is two and one-half inches in diameter, will produce in its spawning season about four to five million eggs and a Pecten, an inch smaller, only one-third as many. At the same time the scallop liberates into the water from twenty-five to fifty billion spermatozoa, whose duty it is to fertilize the eggs. In the wastefulness of Nature, however, only a few eggs develop to mature scallops, perhaps ten to a litter.

This number, small as it is, is sufficient to maintain the race, but if, as with the lobster, a method could be devised or evolved whereby to save a larger ratio of the eggs, problems like that of re-stocking might be solved.

The development of the egg after it is fertilized has been shown by experiments by Mr. Belding to be a matter of minutes. The usual order of cleavages is observed and to the number of sixteen cells requires only about one hundred minutes. In nine to twelve hours the little scallop has developed ciliæ and can swim by

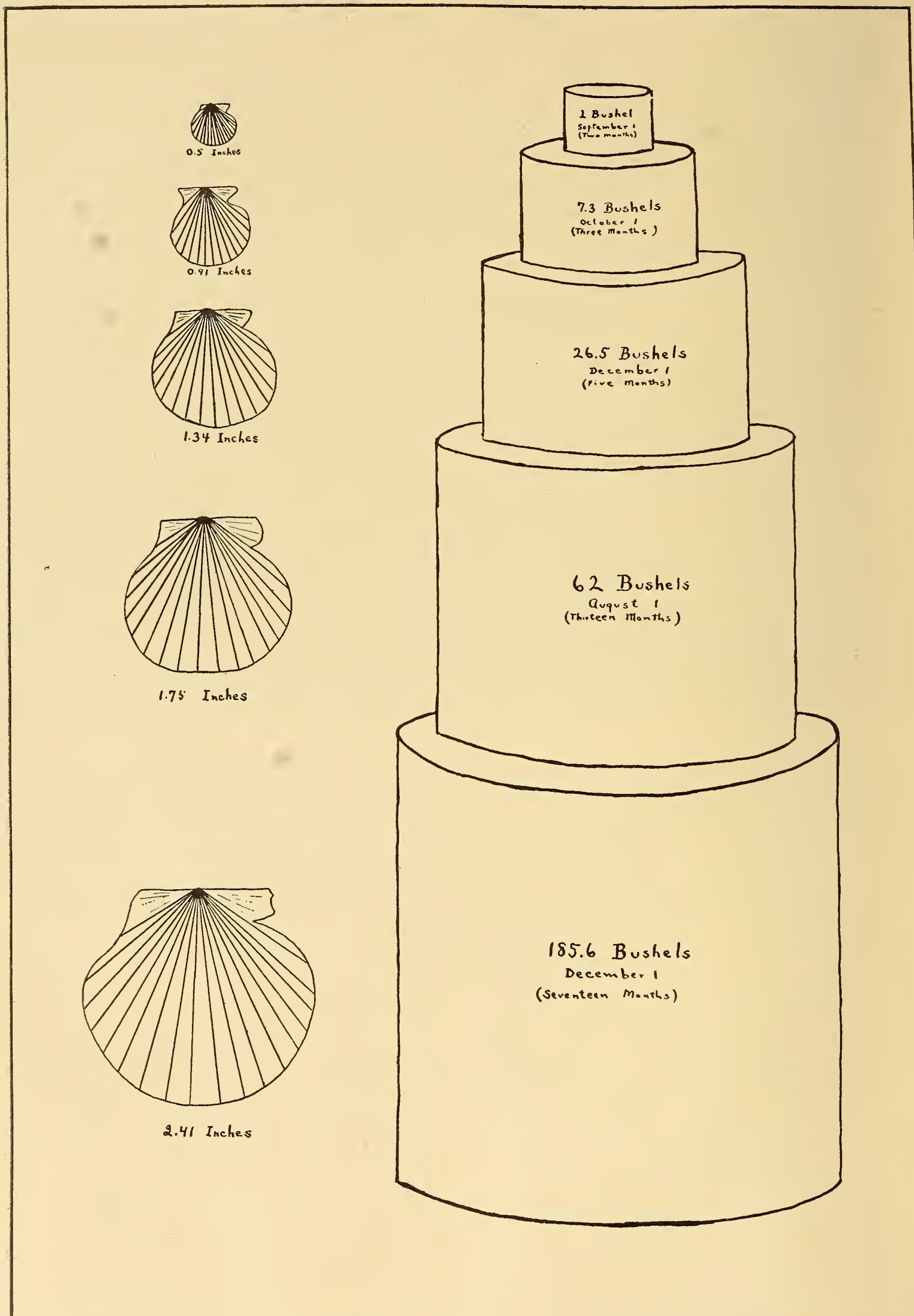
Dredging Scallops off Nantucket.

means of them. It is still a mass of cells of which the outer ones have developed the hair-like appendages and acquired the ability to wave them. The vast majority of eggs never reach this stage. In about half-a-day the shell gland is formed and in a few hours more there has grown over the body of the little swimmer the thin, transparent shell which later develops into the corrugated form characteristic of the scallop. After a while the little creature, here in what is termed the veliger stage, swims by means of a minute paddle and later the foot, which is a distinctive feature in all mollusks, takes its place. Then there is the further growth and development into the form so familiar to those who know the scallop.

Like many others of the shellfish this one has the ability of settling down in some desired place and here it homes itself by the marine mode of mooring. The cable is merely a few fine gossamer threads, although some of its neighbors not far removed in the classification of the mollusca depend largely upon such attachment and spin many threads which have the collective name of the byssus and the popular one of the beard. Such permanent cables have oftentimes a special notch in the valves through which it extends and some even a well-formed, regular hawse-hole.

The byssus of the young Pecten is formed a thread at a time and the number is dependent upon circumstances, more being necessary where there is a current. The older scallops, however, may return to their earlier freedom of youth, and in storm or stress may be at the mercy of the waves. Thus it is that they are not infrequently cast in windrows upon the beach, whence quick removal is necessary if they are to be saved at all.

This is the factor whereby the adult scallop may be forced to change its place



Growth of the Scallop. The shell figures indicate the increase in size of the scallop and the cylinders the gain in volume, in the times indicated, two, three, five, thirteen and seventeen months.

from the farm of one man to that of another, or be swept to sea or upon the beach, and in a sense makes of the scallop industry a real fishery with its proportion of luck. It has been established pretty certainly, however, by the Fish and Game Commission that the limits of a harbor may very well mark the extent of this movement, so that while the individual is handicapped, the community which may have rights in an extent of shore or harbor line will not be sensibly disturbed, no matter at which particular point on the shore the scallops may be found.

A few little bays have been noted along the shore, inlets with narrow mouths, which afford reasonable safety for the individual culture of the crop but these are the exception to the general rule, and it is true that scallops are particularly suited for a communal industry. Such cultivation is not considered in present legislation which is directed towards regulating the individual, specifying in general the closed season, the quantity to be taken and giving attention to the protection of seed scallops. The importance of communal culture is further shown in the possibility which would then exist of restocking barren areas, which under present protection of the seed and the lack of cooperation between towns and individuals is not practicable. Here is suggested the need for State supervision or mediation, since it is true that local rivalries have in the past prevented the restocking of a deserted area from wasteful plenty just across a town boundary.

That there are possibilities in the scallop culture even beyond the conservative estimate of the authorities seems likely when one considers all the conditions. There are about thirty-one thousand acres—nearly fifty square miles—of shore and sea farm suitable for their growth. That which is in good bearing condition today lies mostly south of the elbow of Cape Cod. The shores of Buzzard's Bay and Vineyard Sound, Martha's Vineyard and Nantucket here included, are the best places, with a small distribution at Provincetown, some fisheries along the inner arm of the Cape at Brewster with scattered places where they have been found as far as Plymouth. None are known north of Boston.

It is thus a partial industry affecting only a limited portion of the shore line, and by no means all of this, for on account of the combinations of the circumstances and handicaps mentioned, only a small part of this is in bearing at one time. Future study ought to make more wide the culture and future legislation more easy the sensible regulation of it.

The fishery of scallops under present customs is very wasteful. The only portion that is eaten by man is the great muscle which serves to close the shells and hold them together. This is only about one-third of the meat of the creature and one-fifth of the gross weight including shell. Even at this the scallop has great advantage over the oyster and the quahaug and some over the ordinary clam, although the paper shells that result from quick growth under modern conditions of clam cultivation can reduce this. The other portions of the scallop are used for bait, but there seems to be no good reason save custom, for using so little for human food. It may be that some new culinary development may find here an increase of available food material and make greater and more reliable the demand for it in the market.

THE USES OF OZONE

The uses of ozone for various purposes which add to the comfort of man have recently been widened because of its commercial exploitation. It is used for deodorizing, purifying drinking water, for sterilizing in hospitals, as an adjunct to cold storage preservation, for sterilizing casks and vaults in breweries, in the aging of beer, in improving the air in homes, offices, and public buildings, as an aid in therapeutics and as a bleaching agent. The gas, however, is extremely unstable, and heat and moisture are both unfavorable to its preservation. New processes are being perfected, however, so that the unfavorable conditions heretofore presented are being minimized, and the uses of ozone multiplied.

EHRLICH'S CHEMOTHERAPY

HOW HIS LOGICAL, SYSTEMATIC CAMPAIGN AGAINST CERTAIN DISEASES HAS DEMONSTRATED THE VALUE OF SCIENTIFIC METHODS IN THERAPEUTICAL PROBLEMS

BY HENRY P. TALBOT

Chemotherapy has been called "a new science." It should, rather, be regarded as the designation of a scientific field in which therapeutics and chemistry intermingle in the solution of problems involving the principles of both of the older sciences, much as do physics and chemistry in so-called "physical chemistry," which is not, on that account, regarded as a "new" science.

Therapeutics is defined as that branch of medical science "which deals with the composition, application, and modes of operation of the remedies for disease." But it has now taken on a somewhat broader, though less exact, meaning, and is understood to include the general administration of medicine, questions of hygiene and dietetics, and much that has to do mainly with the general well-being of the individual. That chemistry must be, as it has been for centuries, inseparable from the study of therapeutics is obvious, and the advance from the simplicity of the theory of Geber, according to which the animal organism was made up of only "sulphur" and "mercury" to our still very imperfect knowledge of the complex changes of physiological processes is, indeed, remarkable. But modern medical and chemical science is not content with the mere alleviation of the ravages of existing disease, that is, with the modifying or assisting of functions temporarily disturbed, but has struck more directly at the root of the trouble by devising means actually to destroy the causative agents and thus arrest the disease, or to render the animal organism inhospitable to these causative agents, as, for example, through the anti-toxins and the methods of preventive medicine in general.

All this had been done even before the advent of chemotherapy. What, then, is new about this combination of scientific effort in two allied fields? Essentially this: It is a logical, systematic campaign against diseases which are caused by the infection of the animal organism by parasites (i. e., bacteria or protozoa) by means of chemicals which have not been found by empirical and more or less haphazard methods, but have been synthesized and built up solely for the purpose in hand, and as the result of researches which have called for the highest type of accurate observation and analytical reasoning for their execution. In this way it has been found possible to devise means by which the animal organism can be sterilized with respect to the parasites in question, and the consequent symptoms of disease can be arrested.

The development of this field is due almost entirely to Professor Paul Ehrlich, of Frankfort, and his co-workers. Dr. Ehrlich was educated as a physician, but has now become also one of the most accomplished and able investigators in the field of synthetic organic chemistry. A conception of the significance of his work can, perhaps, be best obtained by noting important phases in its progressive development.

More than thirty years ago Ehrlich began using coal-tar colors in his physiological studies, employing them as stains for preparations to be examined under the microscope. It is, of course, now commonly known that certain dye-stuffs appear to have a selective affinity for certain tissues of the body, or for certain parasites when residing within it, and these stains are in every day use by the pathologist. But it was not so thirty

years ago, and Ehrlich first found that a dye-stuff known as methylene-blue, and its congeners, were the only colors which would stain live nerve tissue, and drew from this the important inference, which is at the basis of chemotherapy, that this was because of a particular receptivity for these dye-stuffs on the part of these tissues or parasites. It is easy to understand something of the importance of this use of these stains, or dyes, if it is recalled that the changes produced in the individual cells or tissues by drugs are not detectable even under the microscope in most cases, and that it is only through these stains that a knowledge of what has actually happened can be even approximately learned.

Ehrlich concluded from his observations that it was probable that, since these tissues and parasites possessed this receptivity for these specific bodies, there must be some definite effect produced as a result of the combination, if combination it were, and proceeded to conduct investigations in this direction. After some time these researches were rewarded, and in 1890 Ehrlich and Lappmann published a paper on the pain-relieving properties of methylene-blue, and, later, Ehrlich and Guttmann found that the same dye was fatal to one type of the plasmodium, the parasite which causes malaria. As the latter field of investigation, that of the effect upon parasites, appeared very promising, they turned their attention to a particular class of parasites known as trypanosomes, because these could be more easily studied by the inoculation of mice.

The disease-producing parasites are sometimes of vegetable origin, as the bacteria, and sometimes of animal nature, as the protozoa. The trypanosomes are worm-like bodies, somewhat larger than bacteria, belonging to the animal class, and the diseases which they produce prevail most generally in tropical countries. Of these diseases, surra, most generally known in India among cattle, dogs and camels; nagana (tsetse-fly disease), known in Africa among animals in general; and mal de cadaras, known in South America among horses, are typical, while man is also attacked by the sleeping sickness in the tropics. The scourge of syphilis is produced by a parasite known as the spirochete, which is closely allied to the others named, although it is still undetermined whether its nature is animal or vegetable. As will be seen, this particular disease has been found to be one of the most amenable to treatment.

As a result of his researches, Ehrlich formulated a theory regarding the behavior of the cells of living tissue, or of parasites toward foreign bodies. He conceives them as made up of a central "dominant body," which throws out "side-chains," to which he later gave the name receptors. These are of variable character, some being nutrient receptors, and others chemo-receptors, that is, receptors or certain definite chemical elements or groups of elements, known in chemistry as radicals. In a crude sense, the receptors may be likened to locks, and the nutrient or chemical bodies as keys, each fitting a particular lock, as, for example, the dye-stuff methylene-blue, already mentioned. The combinations thus effected may be beneficial to the cell, as in the case of the nutrients, or they may result in the poisoning and death of the cell, as in the case of the methylene-blue when brought into contact with the type of plasmodium referred to above, or quinine for plasmodia in general, a specific remedy for malaria discovered by empirical research.

Ehrlich and his co-workers, with extraordinary skill and industry, prepared several hundred dye-stuffs, studying the varying effects of alterations in chemical structure, each new compound having been logically selected as the result of laboratory tests of its parasiticidal efficiency. Of all these, very few finally withstood severe tests, possibly not more than ten in all, but the fact was established that it was possible in certain cases to sterilize the animal organism with respect to parasites, by this means, without, at the same time, poisoning the animal itself. They were also able to establish certain principles as to the chemical structure of the dye-stuffs most likely to

be effective. They encountered, however, many difficulties. A dye which would attack and destroy a given parasite in a particular animal would not always do so in another species. Symptoms of disease would sometimes recur after varying intervals, and the parasites would then often exhibit peculiar resistance to further attack.

While these researches were still in progress, Uhlenmuth and Salmon published an account of instances of marked success in the destruction of the spirochete of syphilis, and the arrest of the disease, by the use of an arsenical compound known as atoxyl. Secondary and seriously harmful effects to the patients were, however, the consequence of this treatment, but the parasiticidal properties of this compound were so marked that Ehrlich turned his attention to it, in an attempt to so modify its effects upon the animal organism which was harboring the parasites, that its curative power might be made available.

The task was by no means a simple one. He first established the composition of the atoxyl as a para-amido-phenyl arsenic acid. The vast amount of work already done with the dye-stuffs indicated certain lines of probable success, which, nevertheless, was only attained on the synthesis of the six hundred and sixth organic compound by Ehrlich and Kata, sometimes known as "606," and now designated salvarsan. Chemically it is a dioxy-diamido-arseno-benzol, in which arsenic is associated with structural groups akin to those found in the dye-stuffs. A later preparation "914," known as neo-salvarsan, is said to be a combination of salvarsan with sodium formaldehyde sulphoxalate, which is designed to overcome a certain difficulty in administration of the salvarsan, due to acidity of its solutions.

Ehrlich assumes that the parasite of syphilis, the spirochete, possesses among others, arseno-receptors, and that through the combination with this arsenic compound the parasite is poisoned and dies. Ehrlich claims that in more than twelve thousand cases in which this drug has been administered by him, no single case of poisoning has resulted. The administration of the drug, which is intravenous, or intramuscular, requires, however, considerable skill and care. The treatment with salvarsan is often combined with that of mercury. There seems to be no doubt that this preparation exerts a specific and destructive action upon the spirochete, and has already resulted in the alleviation of an enormous amount of suffering (often hereditary and undeserved) from this dreadful scourge. It is still too early to make final statements as to the permanence of the cures effected although there is much reason for hopefulness. It should, however, be noted that this chemotherapeutic treatment, unlike the anti-toxin treatment for certain other diseases, does not at all produce immunity from later infection from the same disease. Indeed, there is some evidence to show that cases of re-infection are distinctly harder to treat successfully than those of initial infection. The cure of advanced cases of the disease naturally, presents greater difficulties, because of secondary disturbances of the vital organs, but many of these have been materially alleviated.

The progress made in the chemotherapeutic treatment of diseases produced by other trypanosomes, notably that of the "sleeping sickness," has been less marked up to the present. Something has been gained, but no specific drug comparable with salvarsan in its efficiency has yet been found.

It is, however, recorded that in Surinam a hospital was established to treat cases of another tropical disease known as the yaws. In the course of eight days three hundred and twenty-eight cases were admitted, and at the end of fourteen days the last patient was discharged, cured, and the hospital had to be closed.

In another field the work of Ehrlich has led to procedures which are of the greatest promise in the study of the processes involved in the progress of medical and physiological research, namely, so-called "vital staining." By means of the

injection of dye-stuffs into living organisms, it is possible, because of the selective receptivity of certain tissues or parasites, for a particular color, to trace the movement of bacilli, and to watch the changes which they occasion in the living organism itself. The same procedure is employed in the study of healthy tissue.

To Ehrlich's clear, analytical mind, exceptional executive ability, fine technique, and extraordinary industry is due not only the procedure by which certain particular diseases may be arrested, but a splendid example of logical attack upon other similar problems, which offers great promise for the future, even though, as in the case of the anti-toxins, one marked success may not be at once followed by others of equal moment. He has demonstrated, in a way which cannot be detailed in the scope of this article, that the test-tube experiments made in the laboratory with a particular drug upon a special parasite cannot be alone relied upon as an index of the effect upon it of the same drug when it is harbored by the living organism, since the action is essentially modified by that organism, and he has advanced theories which at least help in the understanding of the possible reasons for the variations in behavior thus observed. Even though Ehrlich's chemotherapy may not be, in an exact sense, a "new science," it must be acknowledged to be a most fruitful and helpful combination of the principles of two well-recognized and time-honored sciences for the benefit of mankind.

LIQUID AIR AS AN EXPLOSIVE

When liquid air is suddenly heated, for example by an electric spark, it will explode. Early attempts to utilize this property for blasting purposes were rendered futile because of the difficulty of getting the liquid air in place and igniting it before it had completely evaporated. A German has succeeded in overcoming this difficulty by first placing the cartridge in position, performing the necessary operations of tamping, and lastly introducing the liquid air into the cartridge through a small tube.

The liquid air can be prepared by a cheap process at the place of consumption, in fact in the mine itself. This does away with the possibility of the lamentable accidents that so often attend the transportation and storage of dynamite. Liquid air has the additional advantages that it cannot be stolen for unlawful purposes and that the gas formed by the explosion, air, is beneficial rather than detrimental to the miners. E. B. S.

DETECTION BY ULTRA-VIOLET RAYS

It has been the custom of successful check raisers to use chemicals for removing the written matter upon a check and then filling out the body in close imitation of the original. The most successful criminals of this type are able to effect this alteration in a check in such a manner as to make no change in the texture of the paper and leave no trace of their work. Professor Woods of the Johns Hopkins University has found that by photographing a check suspected of being raised, by means of ultra-violet rays, the erasure can be detected. In cases where even a high power magnifying glass was unable to show any tampering with a raised check, Professor Woods has photographed it using ultra-violet rays, the print clearly showing a smudge where the erasure had been made. This new method of detection differs from the chemical processes heretofore used in that no chemical change is made in the document itself.

AMMONIA AS A DISINFECTANT

It has recently been discovered that ordinary ammonia is a powerful disinfectant even for virulent diseases. The bacilli of cholera and typhoid were killed in two hours by allowing an aqueous solution of ammonia to evaporate in a closed space. The bacteria and spores of anthrax yielded to the same treatment in three hours and diphtheria in eight. The method is simple, cheap and not at all injurious to the furnishings of the room. Linen may, of course, be disinfected by washing in this liquid.

E. B. S.

A FALLING CHIMNEY

A PHOTOGRAPHER of the *Newark Evening News* was fortunate in securing the picture of a falling chimney as it was being razed, reproduction of which appears on this page. The procedure in demolishing the chimney was to take down part of the masonry just above the base, inserting wooden wedges and timbers into the slot and then burning out the underpinning, so weakening it that the chimney would tip over.

It is interesting to note the similarity of the fractures on this chimney and the lesions produced on the chimney in another picture on this page, which was left standing after the earthquake at Messina in 1910. These lesions indicated clearly the direction of the earth wave. The last picture is taken from SCIENCE CONSPECTUS, February, 1911.

The Italian Navy has recently equipped a new towboat with Diesel oil engines of the four-cylinder, two cycle type.

Science Conspectus is published December, January, February, March and April.

DOCTORS OF CIVILIZATION

Read the terse yet masterful account that Thucydides gives of the "Black Death," a scourge which, despite their remarkable civilization, the ancient peoples clustered in southeastern Europe and Asia Minor were unable to combat, or peruse Pepys' description of the terrible ravages of the Great Plague in London, and the thought strikes home that the gregarious instinct of man cannot be satisfied without paying a tragic toll. The diseases of perilous occupations, the accidents due to unprotected machinery, the ills obviously caused by poor ventilation, all these can be avoided by the ingenuity of the architect and the engineer. But the pests that have decimated even a rural population are not prevented in any obvious way. Their origin is hidden in wells that apparently yield only pure water, in the bites of insects apparently harmless. They are, in truth, diseases of civilization, which require for their eradication scientific investigation as painstaking and self-sacrificing as the researches that have given us the wonderful antitoxins and sera by which we cure typhoid fever, diphtheria, pneumonia and other maladies, formerly considered fatal.

Not until the bacteriologist with his microscope and his stains had discovered the germs, invisible to the naked eye, that are responsible for most of the ills which flesh is heir to, did it become possible to create the modern profession of sanitary engineering—to educate, in a word, the doctor of civilization. Prevention is the watchword of that new profession—prevention of the conditions under which deadly bacteria may thrive and prevention of the transmission of these bacteria should they breed. Not without the sacrifice of men who could ill be spared has this truth been learned. Heroes have been found, willing to subject themselves to the stings of bacteria-carrying insects, in order to prove that not the exhalations of swamps but the natural inoculating needle of the mosquito is the real cause of some infectious diseases; that miasmas do not in themselves cause ills, but simply aid the breeding of the living vehicles that carry disease germs.

Within the lifetime of living men it was thought that only a physician was fitted to be head of a Board of Health. Even in the smaller towns a medical man is still found intrusted with the well-being of hundreds and perhaps thousands of town dwellers. Gradually, the new doctor of civilization, the sanitary engineer, with the ills of individual human beings the public health expert trained to cope not but with epidemics that devastate whole

communities, is coming to the front. Such is the need for these men that our technical institutions are now offering courses in sanitary engineering. To the Massachusetts Institute of Technology belongs the credit of having, years ago, established the first of these under the guidance of Prof. W. T. Sedgwick. Other institutions soon followed. They have all justified their existence by graduating many students, now actively and successfully engaged in public health work. Not many years will pass when the health of every community will be intrusted not to a graduate physician but to a trained public health expert.—*Scientific American.*

SURFACE COMBUSTION

It has been noted that if a mixture of gas and air emitted at high velocity, as from a Bunsen burner, is directed against a red-hot fire brick held a short distance away, the mixture will burn at the surface of the brick. This phenomenon is known as "surface combustion." A useful example of this application is the heating of crucibles placed in a furnace and packed in a highly refractory granular material. The explosive mixture is forced into this granular material through an opening in the lower part of the furnace below the crucible and when properly adjusted, combustion will go on quietly, without a flame, within the granular material surrounding the crucible, producing a state of intense incandescence. The advantages claimed for this system are that the combustion is greatly accelerated by the incandescent surface and can be directed upon the object where the heat is required. The combustion is perfect with a minimum excess of air, and the attainment of very high temperatures is possible.

One valuable application of the process is known as diaphragm heating. The diaphragm is made of a granular refractory material held together by a suitable binder which is of porous structure so that the combustible gaseous mixture can flow through it. When the gas is turned on and ignited above the surface of the diaphragm it will first burn with a flame but as soon as the diaphragm becomes heated the flame will disappear, combustion taking place at the surface of the pores of the diaphragm. The temperature is regulated by adjusting the amount of gaseous mixture supplied. By this means temperatures can be produced far above the melting point of platinum. A muffle heated to a certain temperature by ordinary means was found to require 105 cubic feet of gas per hour, while the same muffle heated to the same temperature by surface combustion required only 43 cubic feet of gas per hour. The most important application of surface combustion is in heating steam boilers which has recently been successfully tried although the underlying idea involved is not new.

CORROSION ACCELERATED BY PAINT

With reference to the protection given to iron by paints, two prominent German chemists report that the corrosion of the iron plate was increased by certain of the commoner paints. In one of the tests brightly polished iron plates were covered with the following paints; white lead, zinc white, red lead, iron oxide, white lead and lampblack, zinc white and lampblack. These plates were then subjected to the action of steam from water boiling in an open furnace, for a whole day and the paint was then dissolved. Strange to say, under the single coats the iron was not at all rusted, but under the double coatings there were plain indications of attack by rust, the rusting being increased as the number of coatings were multiplied.

A HIGHWAY EXHIBIT

During the next year the State of Washington will spend $8,000,000 on road construction. At Olympia, Washington, various paving companies are laying samples of roadway 16 ft. wide and 100 ft. long in accordance with their own specifications which are filed with the State Highway Department. This stretch of throughfare forms a part of the north and south highway throughout the state.

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DOOM OF THE LOBSTER

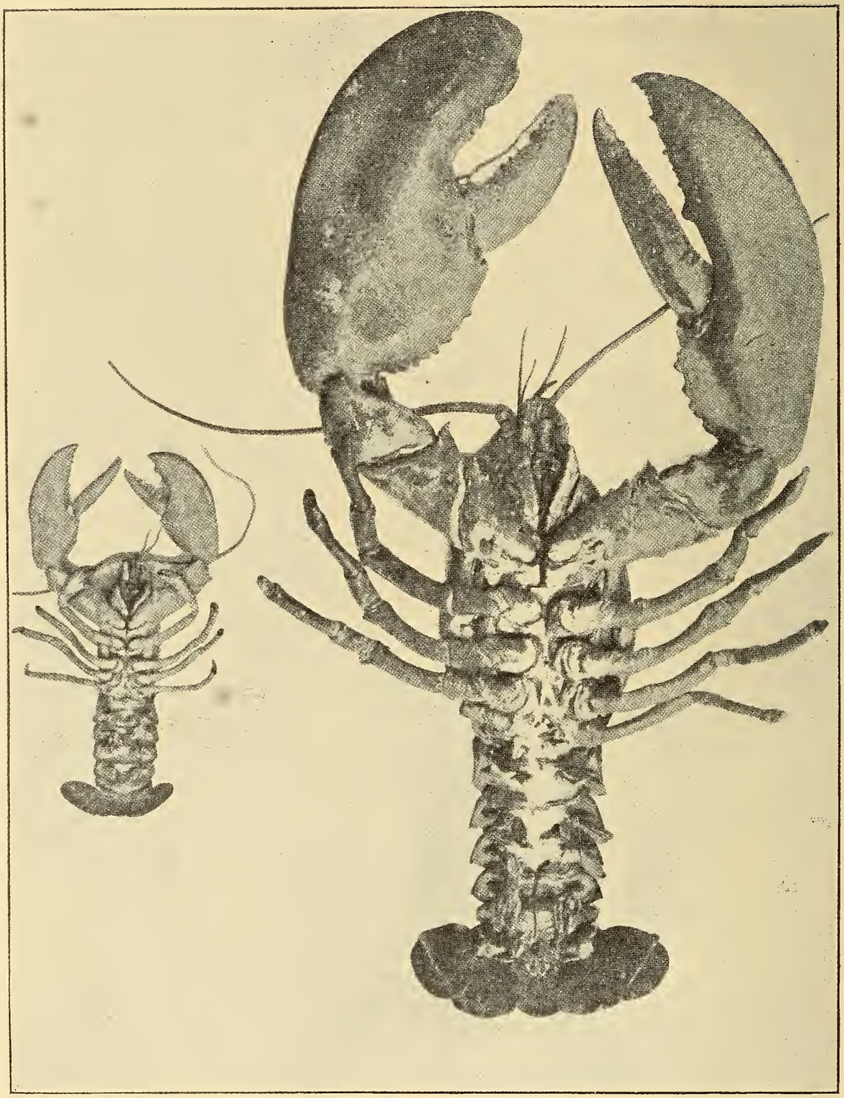
PRESENT FISHING METHODS MEAN COMMERCIAL EXTINCTION. REMEDY IS SIMPLE AND PRACTICAL BUT NEEDS INTERSTATE AND INTERNATIONAL UNITY OF ACTION

BY JOHN RITCHIE, JR.

THE twentieth century methods of fishing for lobsters present a direct violation of fundamental principles of conservation, being a chapter in the utter lack of effort on the part of man to take any heed of the future. The ruthless destruction of large game and the extermination in this country of the buffalo are other phases of the wastefulness of man, but these affect but little his real comfort and his sustenance. The commercialism that injures closely settled places, as does the "robbing" of coal pillars at Scranton, is a grievous waste of money that the public must bear in the end, but this inconveniences rather than injures, provided of course the city land owners can get without too much legal delay or monetary loss the value of their sunken estates. The lumber operator works great hardship from the point of view of conservation, but his ravages and waste and even those caused by the conflagrations which follow in his wake will almost always be repaired by Nature. But the lobster can see for himself no other ultimate—and ultimate here means also proximate—fate but to be practically exterminated, for the simple reason that those now in the industry seek to gain from it the utmost that it will afford, without a care for the morrow, while legislators take their cue from those who are seeking the gain. States hold their hands for they fear the competition of other states that are less restricted, while governments keep aloof from what might be infringement of states' rights. And all the while the destruction continues.

Lobster fishery today has for its motive commercialism of the kind that may be expressed by "for what is in it." There is only very locally any excitement of the chase which has been the excuse for the extermination of the larger mammals. It does not present the economic question of gaining what can be gained in what seems at best an insufficient supply, as in the Pennsylvania coal, while there is afforded no real opportunity for natural restocking as in forestry. Wherever man has fished the sea for lobsters, and that is everywhere that they have abounded, the supply has been depleted.

There is no one in authority who does not know of the enormous decrease in the lobster supply and that commercial extinction is the fate of the crustacean unless matters can very quickly be mended, and at the same time no individual in authority has the means by himself to solve the problem. Matters of this character cannot be righted till the people understand the situation. There was short shrift for the real food adulterator when the people learned of actual food conditions; there has been rapid improvement in water supplies



Relative Sizes, the smaller one weighing $1\frac{1}{2}$ lbs., the larger one, 23 lbs.

since the people have learned to connect with impure ones the dread name, "typhoid," and the public now educated is demanding the proper protection of the healthy from the dangers spread about by tuberculates. An education of this kind must underlie the establishment of principles for the sane fishery of the lobster, before progress toward that object can be assured. There is even at this late day no reason why the lobster cannot be maintained as a regular, constant element and one of great importance, in the food supply. But this means that the principles known to the scientists must be recognized by the people, so that with their support the authorities can act along those lines which they already realize are the only ones bearing hope. What should be done has already been formulated, and the first statement of the principles is to the credit of Massachusetts, whose chairman of the Commissioners on Fisheries and Game, Dr. George W. Field, first showed that present methods are wrong and must be reversed.

Dr. Field is a Massachusetts man whose training fits him for the consideration of just such problems as this. Graduated at Brown, with a Ph.D. from Johns Hopkins, he has been the investigator at the Smithsonian table at Naples, a member of the instructing staff in biology at Brown, Johns Hopkins and the Massachusetts Institute of Technology, from which latter college he went to the Massachusetts commission for a year as biologist, and since 1904 has been its chairman. He is the first man in this or any other country to look properly at the lobster question. His utterances and published statements of a dozen years ago stand today high in the estimation of up-to-date heads of fishery departments. The other methods have been tried out and not with success. His suggestions are philosophical and scientific, and are worthy of a better understanding by the public.

"If we would preserve this fishery," writes Professor Francis H. Herrick in his classic, "Natural History of the American Lobster," "we must reverse our laws as Dr. Field has ably pointed out, and follow the principles and practices of breeders of domestic animals everywhere—use the smaller and better animals for food, and keep the older, and in this case, by far the most valuable, for propagation." And there is the matter in a nutshell, protection for the fruitful, egg-producing, adult lobster.

The knowledge of scarcity of lobsters is not new. Sweden as early as 1686 enacted restrictive legislation as to lobster fishing, and in this State just one hundred years ago Provincetown required permits, the direct motive here urged being fear of exterminating the animal. There was next a minimum length limit established in 1874 about which time a wave of insecurity penetrated to various lobster consuming countries. In 1877 a British commission considered a number of the sea foods and found evidences of an increased demand and a scanty supply. There were at that time imported into England from France "as many as" twenty thousand lobsters a year, while the whole Norwegian catch was "above half a million lobsters." The marked increase in cost was noted then as now.

A peculiar feature of the English argument was an objection to putting back into the sea the "berried hens," or females carrying eggs, for the reason that the eggs were considered more important than the lobster, since "when bruised they are much used in sauce." In 1877 the Irish and Scotch investigators recommended a minimum-size limit of eight inches—or four inches for the carapax or body shell—seven inches for Sussex lobsters, and for all a close season. These have been the changes upon which all subsequent laws have been rung to this day, and with them all there has persisted the decline in the catch of the lobster the world over.

In criticism of this policy—the establishment of a minimum length alone—it is to be argued that the perpetuation of any race must depend upon the adults of breeding age. This principle is unfortunately the very point that past and present lobster laws have failed to realize. The regulations have permitted and have

favored robbing the fishery of its best breeding stock. Permission to take all large lobsters, unless at the moment they are actually bearing eggs, founded as it was on faulty knowledge of the breeding habits of the creature, is now known to be a violation of biological principles. It takes from the race just the individuals most necessary to its continuance. And then with the legal limit at nine inches—it is eight in some parts of Canada—not one in fifty of the lobsters taken has ever laid an egg, while there can be little doubt but that in the interest of the canneries there has been a veritable slaughter of the innocents, although the "grasshopper-size" imputed to them at times has surely its measure of hyperbole. The catch has consumed the adolescent lobsters and the vigorous ones and there are plain reasons why in the case of this crustacean the policy has been most disastrous.

The reason is very obvious, the moment one considers the reproduction statistics of the lobster. The sexes are quite evenly divided. The female lays eggs and carries them about with her for eleven months before they hatch. The litters are biennial. The lobster is adult when between eight and ten inches long—the length varies somewhat—and the first litter is about five thousand eggs. The nine-inch lobster that is legally taken has not in general yet contributed to the perpetuation of the species. For its second litter, the lobster, then two years older and about eleven inches long, lays 10,000 eggs, the third litter is 20,000, the fourth, at about thirteen inches length, is 40,000 eggs, the next litter is again doubled to 80,000 eggs, while the lobster of fifteen or sixteen inches in length may be laying as many as one hundred thousand eggs. The chart makes the folly of present methods more evident in a moment than pages of description. The bottom figures are those of egg-carrying lobsters that were purchased by the State of Massachusetts in the year 1906–07. The length in inches is indicated and the number of lobsters in each group. The columns show relative egg-productiveness. No lobsters in these groups are protected unless they are actually carrying eggs. Dr. Field's suggestion is to protect the large, fertile individuals.

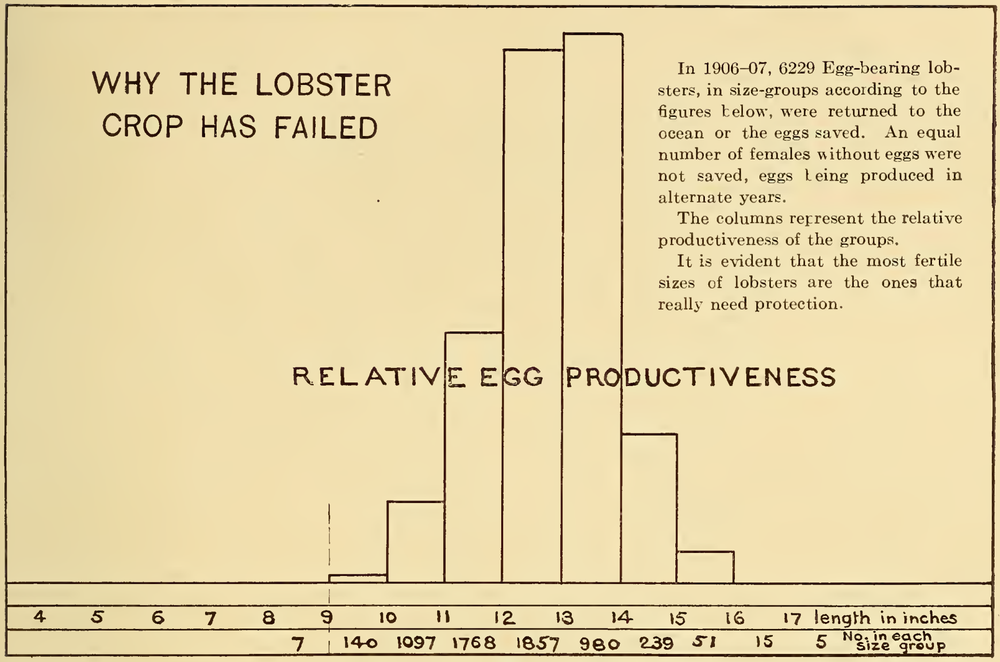
It is well worth while here to review the situation in New England, and that can best be done by noting from the Massachusetts reports what has been the value of the industry, and what has happened to it. Although Maine is a state with a greater total product of lobsters, the statistics and suggestions furnished by the reports of Dr. Field's office are convenient in form and direct to the point.

There are not wanting those who insist that the decline of the lobster is a fiction and that the catch today is as good as ever. To such men, and they are not infrequent or silent at legislative hearings, a single table from the commissioners' report of a year ago to the Legislature is refutation.

	Fishermen.	Traps.	Number of lobsters above 10½ inches	Egg-bearing lobsters	Av. catch per pot
1888	367	26,418	1,740,850	....	81
1889	344	20,016	1,359,645	61,832	68
1890	379	19,554	1,612,129	70,909	82
1891	327	15,448	1,292,791	49,973	84
1892	312	14,064	1,107,764	37,230	79
1893	371	17,012	1,149,732	32,741	62
1894	425	20,303	1,096,834	34,897	54
1895	377	17,205	956,365	34,343	56
1896	453	22,041	995,396	30,470	45
1897	388	18,829	896,273	23,719	48
1898	340	16,195	720,413	19,931	44
1899	327	15,350	644,633	16,470	42
1900	309	14,086	646,499	15,638	46
1901	331	16,286	578,383	16,353	35
1902	410	20,058	670,245	....	34
1903	309	20,121	665,466	....	33
1904	326	19,539	552,290	13,950	28
1905	287	13,829	426,471	9,865	31
1907	379	21,342	1,039,886*	10,348	49
1908	349	19,294	1,035,123*	9,081	54
1909	522	29,996	1,326,219*	11,656	45
1910	390	26,760	935,356*	7,857	35
1911	341	19,773	822,107*	5,488	42
1912	284	16,545	636,203*	4,744	36

* Number of lobsters above nine inches, in these years the legal minimum length.

These statistics have been collected for the State for twenty years and more in conformity with the law. So long as the legal minimum limit in size was ten

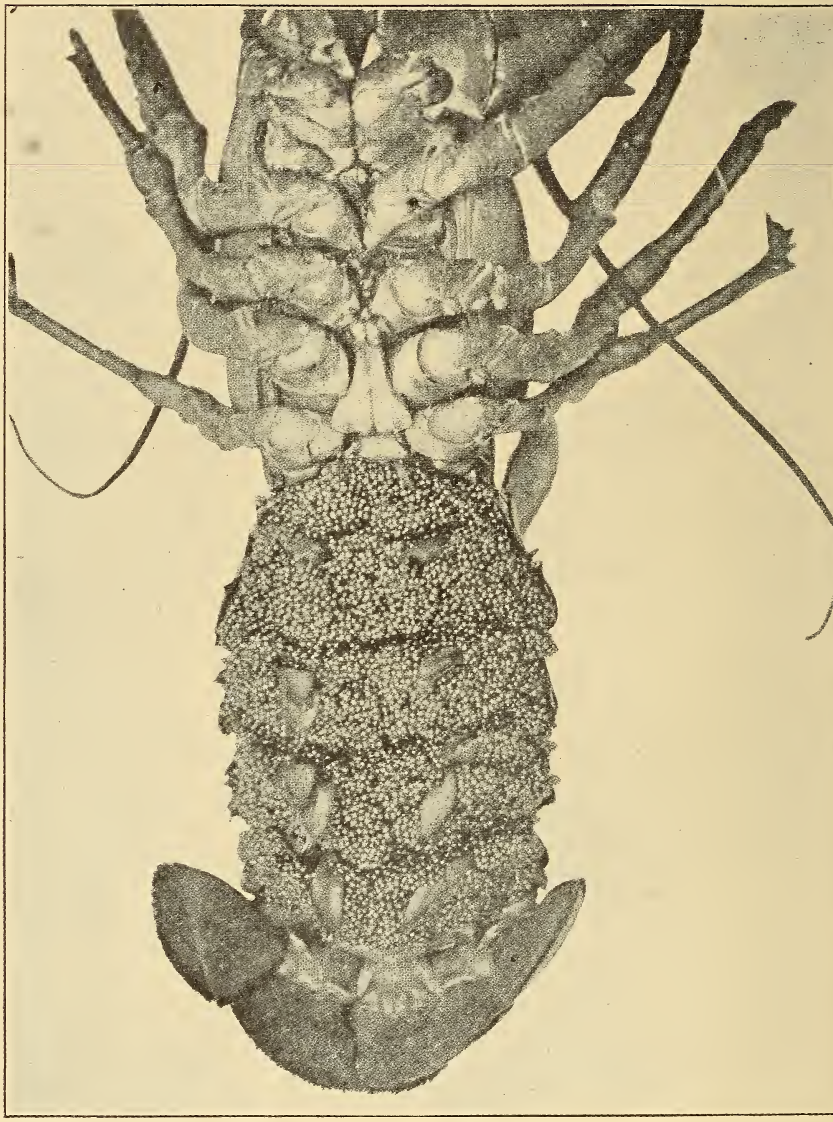


These are the lobsters that the Massachusetts law now protects | These are the lobsters that may be legally taken if not egg-bearing

and one-half inches there was a steady decline, which was arrested for a brief time when the lowering of the limit permitted the larger catch, but this has not served to stop the decrease, merely to put it on another basis.

Taking for the starting point the year 1888, the catch stood at a million seven hundred and fifty thousand lobsters, a figure that has not since been equaled in Massachusetts. The number of men engaged in the business has fluctuated from the 367 of that year to 425, 453 and more recently even to above five hundred but still the catch has declined. The number of traps has remained substantially the same, with a few low years and very high figures for later years, and with this the area of the fishing has increased, but the catch has steadily declined, and with the fading away of the main fishery there comes the very serious element, that the number of lobsters taken with eggs attached to them has declined more rapidly than the fishery itself. In 1889 there was one lobster with eggs to every twenty-two in the entire catch and the decreases are these; by 1893, one in 35; by 1897, one in 38 and by 1904, only one in 42. At the end of fifteen years there were only half as many "berried females" in the catch.

In 1907, to counteract the evident decline in the catch, the size limit was lowered from ten and one-half to nine inches where it is today. The legislation was not in accord with the opinions of the scientists, but was in response to the demand of the men who saw their livelihood disappearing, and the outcome has proved it to have been a disastrous move. It is true that for a year or two the catch jumped up again, to above a million lobsters; it is true that two years later by dint of the unprecedented number of 522 fishermen, working nearly thirty thousand traps, and much new ground, the catch stood at 1,326,000, but now, two to four years later still the catch has come down again to about its old figures and the average per lobster pot is about the minimum. It is evident to him who cares to face the figures that the scarcity



How the Eggs are carried externally by the Female Lobster for ten to eleven months. Original by the R. I Commission

of lobsters at above ten inches in length that was induced by the older regulations has merely been shifted and by continuing the same policy, the smaller ones are just as scarce now as were the larger ones six years ago.

It is when one scans the number of egg-bearing lobsters that a most important phase of the seriousness of the situation is very apparent. The ratio of such lobsters in the total catch was in 1889 one in 22 and under the ten and one-half-inch minimum it decreased gradually but persistently to one in 42 in 1905, and was exciting comment. But the first catch under the nine-inch law in Massachusetts showed this ratio to be one in 104, in three years it had gone down to one in 117 and in 1912 it was one in 135. These figures point clearly to an enormous decrease in the number of lobsters that bear the burden of the continuance of the species.

It is fair to ask here how much reliance is to be placed in such statistics of egg-carrying females, and what they really mean. It should be explained that the eggs of the lobster are cemented to the under side of the tail (see fig.), and are there carried by the female for ten or eleven months till hatched. It is a simple thing for the lobsterman in his boat to brush the creature with a whisk broom or with a mitten and make of it in a twinkling an ordinary, commercial lobster. This has been done a great deal in the past, and is impossible to regulate by any practical system of supervision. Massachusetts has cut the Gordian knot, and so have other states and Canada, by making the egg-carrying lobster a commercial article. The State will buy such lobsters from the fishermen for quite as high a price as the ordinary lobster will bring in the market. It is profitable to the lobsterman to hand such lobsters over to the State, and it is reasonable to assume that the number of lobsters bought by the State is practically the number of egg-bearing females actually caught. And it is an index of the ratio of such lobsters to the whole number. It, furthermore, gives a hint as to the number of females without eggs that may be taken in the non-egg-laying years.

Then there is another figure that is here important, which proves the lobsters to be getting smaller and smaller in the catches. Measurements made in 1905–06 showed that there were as many as 159 lobsters of more than twelve inches in length to every hundred under twelve inches, or three fifths of the whole, while in 1907–08 there were but 75 of the larger lobsters to every hundred smaller ones. The falling off here is almost one third.

It would seem as if there had here been assembled sufficient facts to convince any one that the lobster fishery in Massachusetts is truly in a precarious condition, and that if it is to be saved at all, it is high time to begin. And what is true of Massachusetts is true also of the other lobster-fishing New England states.

Let us look for a while at the world-over condition of the lobster fisheries.

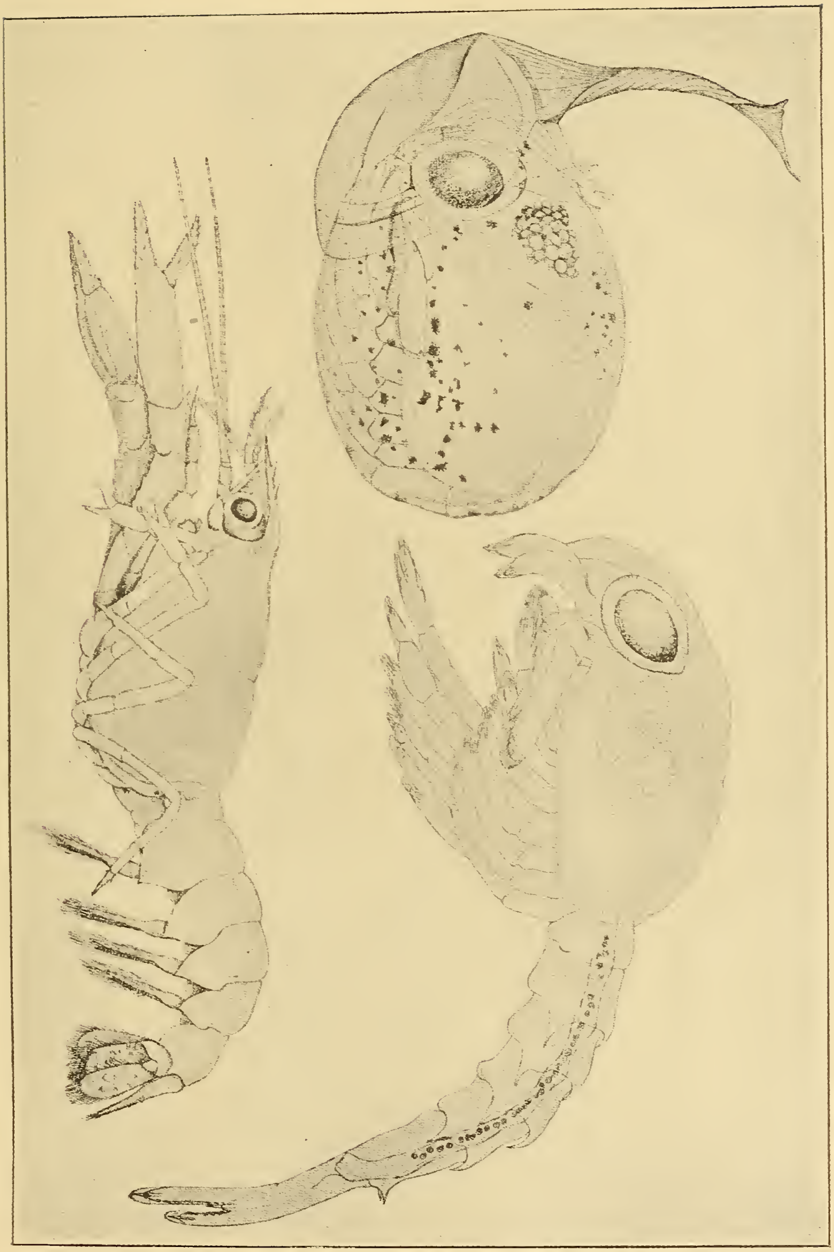
The Decapoda, in which order the lobsters are included, lie in three sub-orders, the long-tailed species like the shrimp and lobster; the hermit lobster and hermit crab, and the true crab. The lobster sub-order is again divided into five groups, the true lobsters, the fresh-water crayfishes, the shrimps and prawns, the spiny or rock lobsters and the warty lobsters. Crayfish, shrimps and prawns are widely distributed and edible. Some of them grow from four to six inches in length and it has seriously been suggested that they be brought from the Pacific Coast to supplement the failing lobster catch of the East. The spiny lobster, which lacks the great fore-claws of the common species, is well distributed through European waters and has always been esteemed for food. The edible portions are small in quantity but good in quality. In eastern America there are species attaining large size as far north as Bermuda; in California fourteen inches in length and three and one half pounds, weight has been reported, while Japan possesses a lobster of the same genus. Both the rock and the warty lobster are found in the Mediterranean; some of the spiny forms are distributed along the

coast of Africa to Cape Town, while in the antipodes, in New Zealand, there has been the taking of species of this genus with considerations of their propagation. No one of these sources of supply seems to be important in the world's consumption. The lobsters of the Antilles are now being caught for floating canneries, and it goes without saying that the supply will not last long; fully twenty years ago Rathbun called attention to the overfishing in California, and today the East hardly knows of the lobster of the west coast, while in Japan, the experiments in propagation seem not to have been successful. It is quite evident, therefore, that if the world is to continue to eat lobster as it is now doing, its dependence must lie in the true lobsters, and of these there are three known species, the American, the Norwegian and the common lobster of Europe.

The American lobster and the European are practically the same, while the Norwegian crustacean is smaller and more highly colored. The catch of the latter is minor in view of the largeness of American measures; the process is by trawling in deep water and the catch is practically all males. If these conditions continue there is a reasonable amount of security to the fishery, for there is here no lobster-pot working day and night; there must always be a fair proportion of the males escape while the females are undisturbed in the important work of producing young. With the common lobster the case is very different and the female has been so seriously handicapped in her province that whether in Europe or in America the decline of the species is evident. The Norway lobster is an inhabitant of the coast of the country from which it takes its name, and is to be found plentifully along the shores of Ireland and Scotland, venturing sometimes into the Mediterranean. The common lobster of Europe extends from the north of Norway down the Atlantic coast and into the Mediterranean, including, of course, the British Isles. It is not found in Iceland; it does not go into the Baltic and its easternmost limit is the mouth of the Adriatic. The great fisheries are Norwegian. On this side of the ocean the lobster grounds extend from Long Island to the tip of Newfoundland at the Straits of Belle Isle, about ten degrees of latitude. In this country it is an industry of New England and Canada, and an industry of importance, for it has meant a million to a million and a half dollars a year to New England commerce, while in Canada the yield is three times as great. In Europe the Norwegian yield may touch two hundred thousand dollars; the French catch, which includes the spiny species, is about the same, while all Great Britain in its best days has surpassed the good years of Massachusetts only by about one third. This means that New England should be able by proper treaty and sensible home management to surpass in quantity the whole European fishery and hold for its own citizens a proper share of a profitable industry.

The lobster touches the pocket of the Massachusetts man, not only in the fact that his industry is passing away, but because he continues to eat lobster and the home supply means not more than 5 per cent. of the state consumption. The citizens are, therefore, expending a million dollars or so for what the general policy has suffered to be lost. The state has permitted an important food industry to slip away till it is now almost out of its grasp. And not only this, its own shortage in the supply has helped in the very large increase in the cost of the article. In a general way the lobster supply may be likened to the classic Sibylline books, and the total price for the remnant now equals the former worth of the whole. Massachusetts is paying to Canada its million or more for lobsters, and it is next only fair to inquire, "Where does Canada stand?"

Today the shores of Nova Scotia, Cape Breton, New Foundland and of the Province of Quebec in the Gulf of St. Lawrence, furnish lobsters to the world. In such a position of security Canada has been practically unhampered in its choice of policy, and, in addition, the mechanism of regulation of such a matter is far more simple than in the United



Upper Figure, Embryo escaping from Egg; Lower Right Figure, Immediately after leaving the Egg; Lower Left Figure, Young Lobster. Originals by Herrick

First Larval Stage. Original by Herrick

States. There was the possibility of a wise control, but it is patent now that the Provinces have but followed the same path as the other lobster-fishing nations, wherever they have existed.

It was not long ago, when the urgency of the situation was impressing itself on New England, that the Canadian policy might have been broadly translated as, "Have no fear, for we, by ourselves, can supply the world." The time has come when the shortage in the crop is imminent and Canada is itself considering the means for conserving its supply.

In the early seventies, when New England really first set about considering its problems, attention was directed in Canada to the general subject and in 1873 it was forbidden to take lobsters in the moult, females with eggs or short lobsters, the minimum being one and one-half pounds weight. The next year there was a close season established—July and August—and a length minimum of nine inches.

There were general variations in the close season; in 1889 the minimum length was increased to nine and one-half inches and after two years trial it was re-established at nine. Then there were experiments in the width between slats in the traps so that the little ones might crawl out, and these, with prohibitions and restrictions on trawling, lasted till 1894. In 1898 a commission was appointed to investigate and the result was the adoption in 1903 of the regulations substantially as they are now. These impose close seasons at different times in different localities with June to August for beginnings and December till May for endings; minimum lengths down to eight inches, different in different localities, the prohibition of capturing soft-shelled or "berried" lobsters, of selling broken meats, of boiling on board vessels, with various restrictions in the technique of catching, and the establishment of the lagoons of the Magdalen Islands for a close locality.

Regulations are comparatively easy to make and the proof of them is in the enforcement, so the Canadian officials have from time to time calmly considered the chances of proper compliance with them.

Now it is to be remembered that Canada is a country of canneries. In 1906 there were 700 such establishments with 12,000 employees, while $2,500,000 of the catch went to these and a scant million dollars to the live lobster industries. And here it is further to be understood that in the United States there is not one cannery, the last ones having been put out of business when in 1895 Maine increased the legal minimum to ten and one-half inches.

The Canadian authorities note that since the canneries are under inspection it is reasonable to believe that with their closing and the storing of the lobsterpots, the requirements of the close-season law may be fulfilled. The brushing of eggs from hen-lobsters is acknowledged to be a trying difficulty, since it would require an inspector or two to each boat to prevent the use of the whisk broom or the mitten. And as for short lobsters, the Canadian Department of Fisheries acknowledges that "it goes without saying that large quantities of lobsters under eight inches and, therefore, illegal, do find their way into the pack of the canners."

The Canadians have reasoned with themselves and in a report for 1908–09 one finds this statement: "The question, therefore, arises, as to whether regulations for the protection of the lobster fishery should be sufficiently drastic to seriously cripple or in many instances automatically close the factories with attendant effects upon the communities where they are operated?" One must make his own inferences as to the actual conditions that four years ago were the foundation for such a report, but it must be remembered at the same time that even so recently as this the symptoms of scarcity in the catch had not been seriously acknowledged in the Provinces. There was belief in existing plenty and a feeling that on account of wise legislation the fisheries of Canada had remained in good condition after forty years of use. According to the report of 1908–09 the Minister of the Marine and Fisheries sent his superintendent to give hearings in various of the coast cities, the outcome of which is the expression of opinion that

Fourth stage of young Lobster, when it assumes normal characters. At this stage it sinks to the bottom concealing itself daytimes. Original drawing by Herrick

Lobster Pots on Prince Edward Island, showing Rings of from Three and one-half to Four Inches. Courtesy of Mass. Commissioners

the canners cannot live if they are obliged "to render a strict observance of the legal size limit."

But there has been steadily coming in an undercurrent of conclusion that even these splendid fisheries are failing. The shortage of 1906 was ascribed to gales and bad weather but the official of the Quebec division says boldly, "It is useless to ignore the fact that in the Gulf division lobsters are becoming scarcer. This has been perfectly apparent for some years."

Today the Canadian authorities are realizing the true conditions, that the inexhaustible lobster supply is coming to its end. To view the new situation a new commission has been appointed, which is already at work. But what is there that can be done?

The lobster was maintaining its balance in nature, before man interfered, by laying from 600,000 to 1,000,000 eggs during its maturity. The lobster of today, in the vast majority, does not arrive at its first, tiny litter, let alone the enormously larger litters of later years. The present laws protect the young just so long as they are of no avail in maintaining the race. By legislation founded on mistaken knowledge of the story of the species, they are left from that moment and are the meat of any man who catches them. The policy of the future, if it is to be a successful policy, must reverse existing protection and care for the mature individuals, and the sooner the people realize this simple principle, the better the hope for the future.

Protection has been sought by a close season. The biological absurdity of this may be shown in a few words. A close season may be useful just to the extent that it stops the fishing. The catch in nine or ten months will probably be less than that for the twelve months. Then the demand is lessened when there are months in which such demand is illegal. But to have a real value the close season should correspond to the breeding time of the animal protected. Since the lobsters breed only every second year and

carry the eggs for eleven months, the question of what is not a closed season is a complicated one. Inasmuch as there is no correspondence between the close season and the breeding season, authorities have come to have little belief that it has any value whatever.

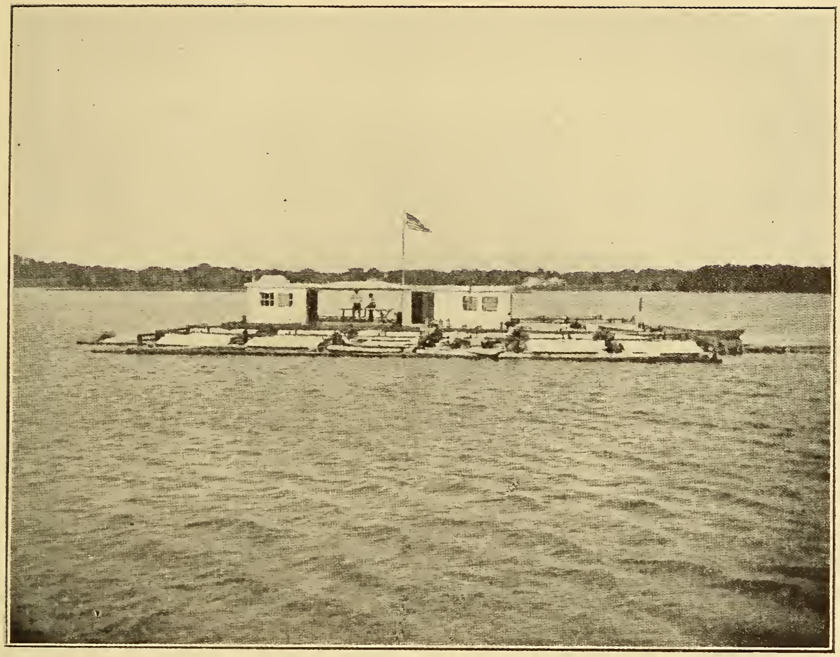
There is next to be considered the place of artificial propagation in the plan for restocking depleted waters, for it has been a plan upon which much has depended. It has had the consideration of the strongest scientific men, Herrick and Mead among them. It has, furthermore, been carried to complete scientific success in the hatcheries of Rhode Island and those of the United States Government, while Canada has hatched and turned into the water not less than 500,000,000 fry in a year, the totals for the duration of the experiments being in the billions.

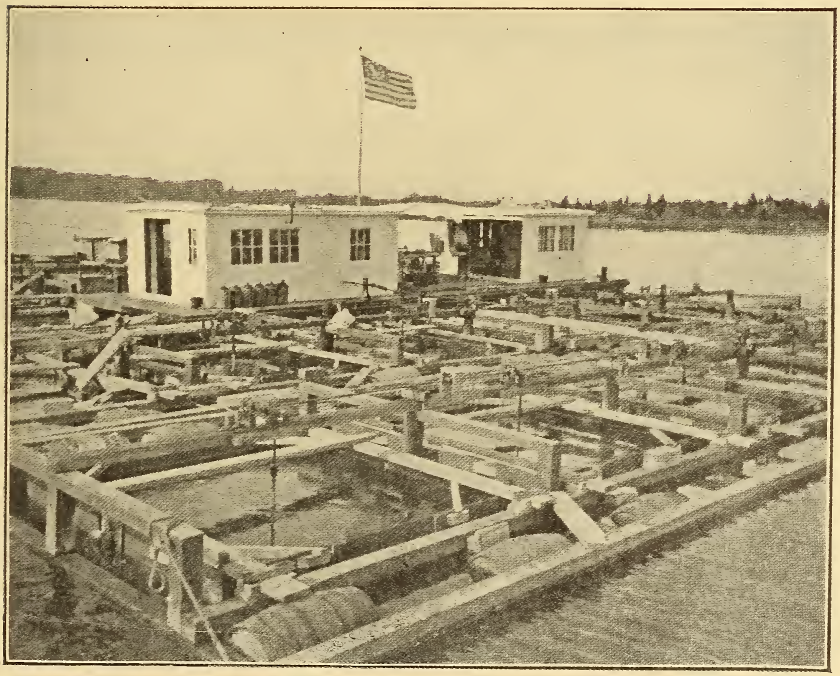
Under natural conditions the young lobster, once released from its neat packing in the egg, begins to show the characters that are prominent in the adult form. The great eye, the many legs and the jointed tail, are among these items. Belonging to the group of creatures encased in unyielding armor, Nature has made the provision here, as in the neighboring group, the insects, for a complete change of shell. When the lobster is too large for its outer case the case is cracked and falls off and a new one is made up from secretions of the surface of the body. Each time of moulting is a season of weakness, for without its hard crust the lobster is at the mercy of enemies.

During the first year of its life the lobster moults fourteen or fifteen times, but this rate is not long maintained and by the fourth year falls to every three or four months. When approaching full size there are few moults. During the first two weeks there are three moults, the real lobster form being taken on at the fourth one. The fry is then a strong swimmer and takes on the habit of going to the bottom, hiding among the rocks and burrowing in the sand. In its earlier stages the young lobster is the food of surface-feeding fishes and other lobsters, for these creatures are cannibals, and there is an enormous mortality; at the bottom it is much better protected. The two problems of artificial cultivation have been, therefore, to prevent cannibalism and to maintain the fry till past the fourth moult.

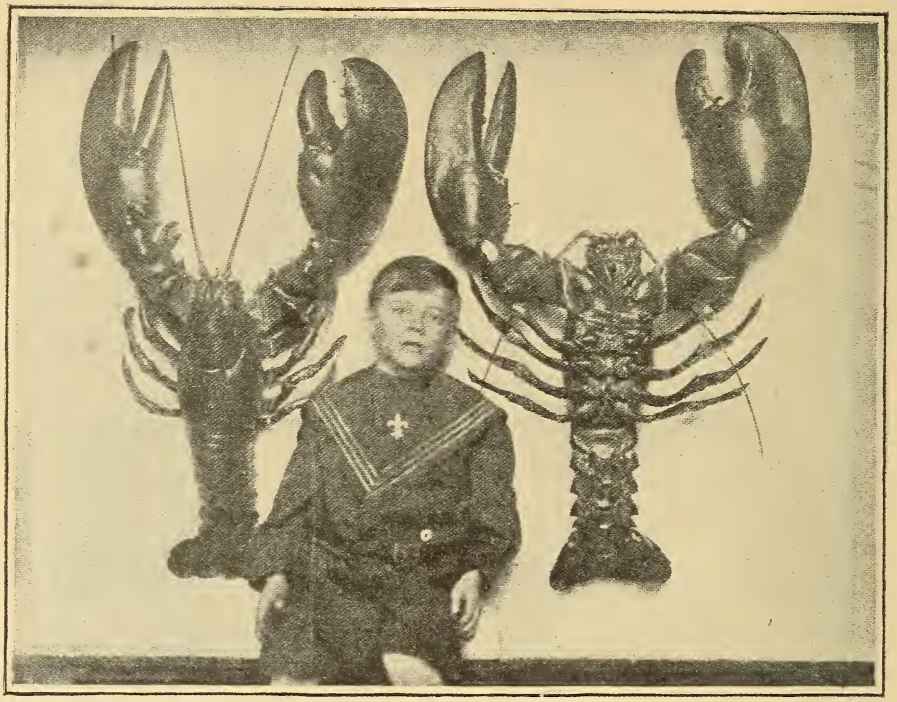
The extent to which Rhode Island has been interested in the hatching of lobsters may perhaps be most quickly judged by the accompanying illustrations. (Figs. see page 143.) The pictures illustrate the outfit at a distance and the houseboat and tanks in some detail. They present the developments by Dr. Mead, and have had the approval of scientific men. So far as Rhode Island is concerned, it is merely necessary here to say that Dr. Mead has been displaced, some alleging that the reasons were political. At all events it is reported that the Wickford hatchery is not at work this year and it is further true that in Massachusetts neither at Wood's Hole nor at Gloucester is there at present any Government work.

With this in view and the fact that all the great hatcheries in Canada are releasing only about 500,000,000 fry a year, the question comes in whether artificial propagation has not its economic limitations. Ten mature lobsters might produce a million eggs and care for them while five thousand such creatures—about the catch of "berried" lobsters in Massachusetts till today—would be doing naturally and without cost a work equal to that of the Canadian hatcheries. It is certainly very evident that man's efforts can be but puny when compared with the millions and billions of eggs that mature lobsters will easily produce if they can only be permitted their chance. On the one side there is the costly housing of the fry and the bringing up by hand, which is working at the wrong end of the lever, compared with proper protection of adult, race-perpetuating lobsters. And it is, furthermore, very doubtful whether the best efforts of man can keep up with the demand, for estimates by Herrick place the probable adults in ten years from all hatcheries at perhaps half a million, while in the same time from the same waters there would be taken from half a billion to one billion adults. Certainly a very unequal contest.





General and Nearer View of R. I. State Hatchery Houseboat and Tanks



Large Lobsters

Now there is here one interesting fact, that it has been practically proven that the large lobsters, if permitted to do so, will maintain their race. There is one little corner of the lobster shore, which shall be nameless here, where the supply has not been depleted and where large lobsters are still to be caught. The fishermen hold themselves strictly to conservative and scientific fishing, and woe be to the individual—friend or foe—who transgresses their rules.

The general facts exist, that wherever man has fished the lobster, the crustacean is becoming scarce. Legislation till now has utterly failed to arrest the depletion and artificial propagation has not been adequate to keep up the supply. What is to be done?

Of course there is one way, to fish lobsters just as they are now fished until they are commercially extinct. Then when they have no longer a money value they will be let alone; they will increase naturally, and a hundred years hence, they may again be a toothsome food for our descendants. The other way is to adopt sane and sensible measures for their conservation. The line has been marked out by Dr. Field and the scientific men support his suggestion. He has himself full confidence in its practicability, but it is no longer a matter where Massachusetts can act by itself. Four other New England states and New York must agree upon the same policy, or there would be instant competition. The matter was, however, presented to the governors of New England at the conference of 1908. At this time Dr. Herrick called attention to the grave errors of existing systems, which legalize the capture of the large, adult animals. Nothing, however, came of the conference in this regard. It is not a matter where the Federal Government has the right to interfere for here comes the prerogative of each state to arrange the business of its own citizens when within its limits. Then there is Canada in the competition, so that the question becomes an international one. There can, however, hardly be the doubt

about the awakening of the Provinces to the need of uniform and concerted legislation, and it is to be hoped, in that event, there can be concerted action of the New England states through the Federal authorities to meet the need.

And the needs are after all absurdly simple, a double limit protecting small lobsters at the one end, and at the other and above all the large adults of both sexes; protection of the "berried" lobster; the abolition of a close season and the adoption of a standard trap whose rings shall be so small as to exclude the large lobsters and whose slats shall permit the undersized ones to escape.

Note.—The illustrations are presented through the courtesy of the Massachusetts Commissioners of Fisheries and Game.

The reader who seeks detailed information in the matter is referred to Herrick's unapproachable volume, "Natural History of the American Lobster," in Bulletin of the U. S. Bureau of Fisheries, Vol. xxix, 1909, issued also as a separate in 1911 as Document 747.

VACCINES FOR WHOOPING COUGH

A valuable paper on this subject from Dr. E. Mather Sill appeared in a recent number of *American Journal of Diseases of Children*. Dr. Sill states that:

"Thirty-three cases of whooping cough were treated with the pertussis vaccine, and in all the effect of the vaccine was to diminish markedly the number and severity of the paroxysms and the amount of vomiting.

"Absolutely no untoward effects from the use of the vaccine were noted. There were no complications in the cases in which the vaccine was used. No abscess formation, or even slight temporary inflammation or swelling at the site of the injection, and no general constitutional symptoms occurred. The longest time any of the children coughed was twelve weeks and four days. The longest time any child coughed after it was put under vaccine treatment was nine weeks and one day, the average length of time being four and one-half weeks. The injections were given every two or three days in most of the severe cases, and in the very severe cases every day for a few days, until the symptoms were relieved; the milder cases did not receive the vaccine so often nor so much at a time.

"The cases that were seen early in the attack, before the paroxysms had attained their height, seemed to respond more quickly to treatment and their course was shorter. In all cases, however, after one to three injections, the number and severity of the paroxysms was markedly lessened.

"Some children seemed to respond better to treatment than others, and I attribute this to the fact that the dosage was given irrespective of the age; therefore, the younger children got a larger dose proportionately, and as a rule these latter were the ones that responded most quickly to the vaccine and had the shortest attacks after treatment was begun. This fact is important, since (heretofore) these young babies are so apt to have pneumonia complicating or accompanying pertussis, with fatal results."

In connection with the use of vaccines for prophylactic purposes Dr. Sill makes the following comment:

"A very interesting fact is that prophylactic treatment was instituted by giving immunizing doses of pertussis vaccine to children in a family in which one of the children was under treatment for whooping-cough. These children were watched over a period of two months, and although they had never had whooping cough and were constantly exposed to the disease, did not contract it. It would seem, then, that the vaccine confers immunity to the child injected with small doses. One child of 5 years was given four injections of twenty million bacteria each, over a period of one month; another in the same family, 3 years of age, got nine injections of twenty million each, over a period of one month; neither child developed pertussis."

PROBLEMS OF THE INFINITELY LITTLE*

THE PROBLEM OF THE SIMPLEST MICROCOSM THE BASIS FOR THE SOLUTION OF ALL THE MYSTERIES OF THE UNIVERSE

BY R. B. BOWKER

THE twentieth century may achieve the solution of the problems of the infinitely little. It is these problems which bring the human mind to the confines of knowledge, to that borderland beyond which is the realm of the unknowable. In that realm the finite mind confronts what seem to it contradictions and impossibilities only, dilemmas of which it can grasp neither alternative, questions of beginning or no beginning, of end or no end, of bounded space or unbounded infinity, of limited time or timeless eternity, of tenuous matter or motionless void, which transcend not only time and space, but experience and thought. The spirit of science, the search for truth, cannot content itself short of the most thorough exploration of this borderland, in the hope, eternal in the human spirit, that it may even peer beyond the veil.

The problems of the infinitely little are also, in a sense, the problems of the infinitely great, of astronomy as well as of biology and chemistry. The nineteenth century learned that the macrocosm is an evolution from the microcosm. Moreover, our practical age has found that its inventions are of equal value for theoretical investigation and in the everyday service of man. The microscope, the photograph, the spectroscope, and the bolometer, extensions of our sense-organs, make the invisible visible, and register, in dimensions of micromillimeters, the penultimate facts alike of the cosmos, of life, of matter. Penultimate because beyond the sense-data which their revelations supply, scientific inquiry must proceed with the most delicate of all instruments of knowledge, the scientific use of the imagination. No man has seen or may see a molecule or an atom, yet we have come to know and to distinguish in their several kinds not only molecules and atoms but the corpuscles or ions from which they are built up. Hypotheses inductively developed from known facts are confirmed into laws and generalizations, from which are deductively developed new facts which form the starting-points for new hypotheses; and this "made ground" of human knowledge becomes as firm foundation, nay, firmer foundation, than the facts we seem to see, the course of the sun or the everlasting but everchanging hills.

Says Haeckel of one of his most daring conclusions regarding the chemical relations of bacteria: "I would particularly point out that this very justifiable statement is a pure hypothesis; it is an excellent illustration of the fact that we cannot get on in the explanation of the most important natural phenomena without hypotheses. We can see nothing whatever of the chemical, molecular structure of the plasm, even under the highest power of the microscope; it lies far below the limit of microscopic inspection. Nevertheless, no expert scientist has the slightest doubt of its existence, or that the complicated movements of the sensitive atoms and the molecules and groups of molecules they make up are the causes of the vast changes which these tiny organisms effect in the tissues of the human and the higher animal body."†

In astronomy, now the study of cosmic evolution, the final questions rest upon the physio-chemical cause of solar radia-

* Reprinted from *The City College Quarterly*

† "Wonders of Life," ch. Monera p. 203

tion, the elemental nature of comets and nebulæ, the possible existence within the solar system of star-dust that may condition the zodiacal light, and throughout space of infinitely tenuous matter that may even prove to be identical with the self-contradictory ether, the universal medium of radiant energy. It is the spectroscope which within the compass of the single octave of visible light, with its waves less than a millionth meter long, and the adjacent octaves, refracts the light from the farthest celestial sources into exact wave-lengths, certifies to us with exactness what chemical elements exist in these light-sources, discloses their physical condition, as solid or gaseous, and even from the shortening or lengthening of wave-lengths informs us whether a star is moving toward or from our system. From these spectrograph records the nineteenth century learned that the sun is a molten body with photosphere of gas, containing many but not all of the elements found on the earth, and no other, and that the stars are more distant suns, made up mostly if not altogether from elements known to us on the earth, but usually with fewer elements, varying especially in the different colored stars. Nebulæ, to the hundred thousand, whose light is so faint as to be undiscernible to the human eye through the largest telescope, nevertheless rearrange at a distance of millions on millions of miles the sensitive molecules of the photographic salts, and give us spectrograph records which prove their gaseous condition, though in the spiral stage of their evolution there may be discernible solid or viscous or liquid granules which are the evolutionary beginning of whirling worlds. When in 1901, for the first time since the development of these modern instruments of precision, a new star (Nova Persei) appeared in the heavens in the constellation Perseus—probably from a celestial collision between two dead and lightless stellar bodies such as we now infer to exist in great numbers throughout space—its spectrograph certified to us the existence of the same chemical elements which have been found alike in the earth, the sun and the stars, but with the distinction that a line produced by hydrogen was of extraordinary brilliancy. The spectrographs of the nebulæ show few and simple bands of light, that in Draco showing but three lines, of which only one is a hydrogen line. Here then in nature's elemental laboratory, we press to the very verge of beginnings and find not only that the substance of least atomic weight and presumably the simplest of elements plays the leading role, but possibly that the simplest "elements" are, as it were, in nascent or prenatal stage.

In physics, the knowledge of forces, the science of motion, the chief problems of today are in the study of those ether waves, through that wonderful gamut of 44 octaves which, beginning with the wave-lengths of Hertz vibrations, comparable in wave-lengths with those of sound in air, culminates in the actinic vibrations beyond the octave of light which have a frequency as high as 3,000 million million per second and a wave-length of .1 of a micron, the millionth of a meter. Sound, vibrating particles of air or other matter, is comparatively a gross force, though the mechanism of the human ear can distinguish wave-lengths so short as 8 mm. with a frequency of 40,000 per second. But the telephone has developed for us the translation and transmission of these waves and when Edison pricked his finger with the telephone point, there came the astounding discovery that the sound wave from an entire orchestra and a chorus of human voices, can be recorded in and reproduced from a resultant impression of a single line, whose characteristics are beyond microscopic test. While sound comes from motions of mass, so to speak, most of the other forces are comprehended as radiant energy in infinitesimal vibrations, known to us through their molecular, atomic or sub-atomic effects. Hotness and cold, with their similarly extreme effects on the human body—for frost also "burns"—the result of radiant energy in the octaves of heat, we now know to mean the increased or diminished activity of molecules adding to or taking from the molecular motion of

colder or hotter bodies, self-retained when surrounded by a wall of vacuum as in a thermos bottle. Below the heat octaves there are realms of the unknown into which Hertz and other investigators have been pushing their observations. Above is the octave of light and the half-explored realm of the actinic rays. All these investigations of modern science deal, it will be seen, with the infinitely little, each so called force in coördinate relation to which the analogies of sound have given us the key.

In physio-chemistry, the two sciences merge into each other in the borderland of the infinitely little, in the study of the once indivisible atom and its now ascertained corpuscular constituents. Since Prout in 1815 considered hydrogen to be the primal because the lightest element, that element had been nearly throughout the nineteenth century the basis and standard of all atomic systems, as those worked out by Newlands and Mendelieff in the middle of the century, and it seemed a sufficient marvel that two atoms of hydrogen constituting this molecule could be contained within the space of one 250,000,000,000th of an inch. But at the close of the century the wonders of radio-activity became known to us and the new element radium was found to have a complicated sub-atomic structure, from which corpuscles were emitted in continuous bombardment producing other elements and leaving a residual also unlike the parent substance. And within a decade, the imagination has come to the picture of atoms which are microcosmic planetary systems in which the constituent corpuscles revolve in orbits as the planets, in ordered array, producing in their interplay the wonderful series of vibrations recorded in the spectrographic lines through which the kinship of one element with another is disclosed. Myriads of these infinitely small bodies make up the tiniest atom and the whole universe of matter, and here again the infinitely little is the key to the infinitely great.

An extraordinary application of the methods of the infinitely little to practical purposes is found in the use of cadmium wave-lengths as shown in the spectroscope, to obtain an exact standard of measurement. When in 1790, in view of the uncertainty of the English yard and other "standards," the National Assembly of France provided for an exact standard of measurement which would be re-calculable and therefore never lost, the commission decided to adopt as the standard a ten-millionth part of the earth's quadrant which, as the standard from which all other measurements were to be deduced, it named the meter. No sooner had the measurement of the earth's quadrant been made and the sequent calculations completed and the new standard adopted, than it was found that an error of an appreciable fraction, making the meter 1/208th of an inch shorter than this ten-millionth, had crept in, so that the meter is not the exact standard it was intended to be and could not be exactly duplicated. The Bureau of Standards at Washington is now basing its work of exact measurements on the wave-lengths of the cadmium lines in the spectrum as determined by Michelson's interference method. Cadmium vapor is distinguished in the spectrum by three distinct lines which under given conditions are always of exactly the same frequency and wave-length, the red line of 310,678 vibrations per second, being peculiarly distinct and distinctive. The green line has a frequency of 393,307 and the blue line of 416,735, and these may be used for verification. By counting the number of red vibrations in a millimeter which is twice 1,212.37,* and multiplying and verifying the result, an exact standard for the meter is obtainable which can be remade should the physical standard be lost. Thus from the vibration of a particle of cadmium a result can be obtained which did not prove practicable by the older and larger methods of measuring the length of the pendulum or the quadrant of our earth.

In biology, the study comprehensive of all life on our earth, vegetable or animal, from man back to monera, from climax

* Michelson, "Light Waves and Their Uses," p. 95

to cell, the pressing problems are again those of the infinitely little. Whether we accept the dualistic philosophy of Kant, of spirit using matter as its instrument, or the monism of Haeckel, of matter evolving spirit, we confront alike the fact that sense-impressions are conveyed by infinitesimal changes through the sense-organs and nerves, recorded and associated in the infinitesimal phronema or thought-cells of the brain, and translated again through volition into action by means of infinitesimal changes in nerve-fiber and muscle. The modern inventions of the telephone, the phonograph and the photograph, furnish alike the proof of the transmission and recording of facts by infinitely small variations in physical conditions of the medium and the analogy for the modern view of the physiological method of psychic control. In the relations of psychology with physiology, therefore, the study of the cells which make up the tissues of the nerves, the brain, the muscles, must furnish basic facts. The very existence of the primate, man, in his individual body, is found to be absolutely dependent upon the most primitive structures, those monera or single and simple cell organisms on the borderland between vegetable and animal which we know as bacteria, for the study of which in defence of human life university professorships and extension laboratories have been endowed. A man housed in the body which houses his spirit is thought of in modern science as a United States, a physiological nation, of which the states, counties and towns are the members, organs and tissues, and the individual citizens are the countless myriads of cells, some life-building and others life-breaking, some indigenous to and others foreign immigrants into the body politic, the most of them good but some of them bad, all organized under a government of law and kept in due relation, each in its own function, by the well-ordering of the controlling spirit.

Modern biologists trace both the human embryo and the race history of our kind through successive forms to the gastræa, the "missing link" of primitive animal life hypothesized by Haeckel and later discovered by Monticelli.* This is simply a stomach sac, developed from a sphere made up from simple cylindrical cells, collapsed, so to speak, by the shrinkage of one hemisphere within the other, the inner layer or lining with a central orifice for a mouth differentiating into the nutritive tissue, while the outer layer or skin becomes the sense tissue of the organism, the intervening space constituting the primitive gut or stomach. The cells which make up this collapsed sphere were multiplied by cell cleavage from the single cell, the beginning of embryonic life, into which the parent cells united. The animal was long supposed to be distinguished from vegetal life by sensation, the power of motion, and the digesting stomach; but though in the higher vegetal forms, such as the sensitive plants, the sun-facing sun-flower and other heliotropic plants, and the insect-eating plants, these powers are limited, yet in the protist forms of vegetal life these functions are found to be closely akin to those in the protozoa or primitive animals. The bacteria, indeed, which seem to be unicellular animal organisms, though long classed by some scientists as vegetal, are linked in such gradation with the vegetal chromocea or unicellular plants that some forms are in a borderland between; and all these and other monera or single cell "organisms without organs," the simplest beings having "life," the most primitive forms lacking even a differentiation into nucleus and cell-body, are composed of the simple plasm of which all life-forms are built up.

In the nucleated cell, which is the beginning of life-differentiation, biologists are disposed to attribute heredity to the nucleus, and adaptation to environment to the cell-body or viscous jelly matter. Haeckel goes a step farther in attributing the psychic quality of memory to cells and pointing out that in the inorganic kingdom the crystal is kindred to the cell. The growth of crystals, he

* Haeckel's *The Wonders of Life*, p. 223

asserts, is "unintelligible without sensation," "as we could not otherwise understand the attraction of the homogeneous particles." Thus when a substance is in saturated solution the interposition of a single crystal of the same substance will instantly start the crystallization of the substance from out the solution, while the interposition of the crystal of another substance will have no effect. Biologic chemists, like Loeb, are now seeking to produce life-motions from inorganic combinations, and within the the range of an atom of carbon, an atom of nitrogen from the air, an atom of hydrogen from water, an atom of oxygen from either, and an atom of sulphur, nature indeed builds up a most striking succession of inorganic compounds that may give at least a key to the production of the living plasm.

It is noteworthy that the chromacea, so called from their color, which is mostly blue-green, and the chlorophyll, or green coloring matter of leaves, for the most part absorb and utilize the yellow, orange and red wave-lengths, of light, while Finsen has successfully applied the red light vibrations to the destruction of bacteria in certain diseases, an opposite or complementary effect full of suggestion to biologists. The most clear modern distinction between vegetal and animal life is that vegetal forms have the power of building up this plasm from inorganic matter, that is, are plasm-making, while the animal organisms must get their plasm through the vegetal factories and are plasm-eating. In this round of life, plants thus set oxygen free from carbon combination, while animals consume oxygen, combining it with carbon. But even this distinction seems to break down in some primitive forms. The final question of race history is whether when the earth cooled to a temperature making life possible, these inorganic chemical elements combined "at the psychological moment" into a life-cell from which by cleavage all succeeding life originated. Thus here again the study of life becomes a problem of the infinitely little.

This plasm is chemically composed of carbon, nitrogen, hydrogen, oxygen and sulphur, which five simple elements are the main factors throughout the range of organic life. Of these elements the albuminoids are altogether composed; and as albumin, the proteid which is the white of the egg and an everywhere-known form of this primitive plasm, is found to have a chemical formula $C_{72}H_{112}N_{18}O_{22}S$, a total of 225 atoms, it is probable that every particle of plasm contains hundreds of atoms, possibly in unstable equilibrium like the corpuscles of radium. The combination of these same elements in the inorganic world opens long vistas of analogies. Carbon, nature's most versatile element having six hands or bonds by which it can grasp other elements to itself—in its simplest form a black, odorless solid, absorbing and utilizing therefore light of all wave-lengths and when heated to incandescence returning all wave-lengths as white light—is the foundation in plasm of all animal and vegetal life. Nitrogen, the obstinate element, sensible neither to sight nor smell—which remains free in the air though in the presence of oxygen and because of its instability in combination forms the basis of all explosives—unites with carbon in the simplest possible union to form cyanogen (C N), a colorless, pungent, poisonous gas, burning in a pink flame edged with green. Hydrogen, also colorless and odorless, combines with cyanogen to produce hydrocyanic or prussic acid (HCN), a liquid, colorless but of almond odor, so volatile that it freezes from its own evaporation—a weak acid but the most deadly of poisons to all animal life. An atom of oxygen combining with this HCN produces cyanic acid (HCNO) or an atom of sulphur produces sulphocyanic acid (HCNS), one of the strongest of acids. Here then in the simplest sequence of combination of five of the simplest elements, is the beginning of marvellous permutations leading into the widest possible range of inorganic compounds in protein form—solid, liquid or gas; odorous or odorless; wholesome, inert or harmful; black or transparent; burning with white incandescence or variegated flame—ringing the changes indeed of all physical characteristics, the

greatest transformations produced by the simplest infinitesimal changes. But these combinations are also the beginning of organic life and accompany its fullest development, and within the range of these infinitesimal combinations a vast field of knowledge is yet to be explored.

Thus, alike in the cosmos, in the inorganic sciences and in the study of life, the problems of the infinitely little are our master-key to the final solutions. I venture a further thought toward the solution of perhaps the most vital problems of the physical life of man. Why should two or three harmless elements in combination rob the body of life? Why will light-vibrations of one wave-length produce agreeable or wholesome and those of another wave-length disagreeable or harmful effects? Why is the electric current at one potential harmless, at a higher potential deadly, at a still higher potential ineffective to the human body? Why is one man's meat another man's poison? It is plain that the vibrations which affect our senses change characteristically with each atomic change, and it seems possible that the tissues of each animal body, variable within a given range, are characteristically responsive in their cellular constituency to vibrations of certain character. In such correlation and in such responsiveness of structure and function to infinitesimal vibrations may some day be found the solution of the human mysteries of health and disease, of life and death.

I have not undertaken to speak of those problems of the infinitely little which, in the field of pure science, form the foundation of the magnificent structure of the higher mathematics, or of those others, which, in psychology, developed from the repetition of minute acts—in the moral nature as in the physical body—form habit and trend and character. I have confined myself chiefly within the range of that wonderful unity and continuity which in the physical world extends from the microcosm of chemistry through physics to the macrocosm of astronomy, in which dead matter is linked with or made into living organisms at points of contact in the field of the infinitely little which are still a mystery. It must be confessed that it is not even known that investigators like Loeb have done more than produce the semblance of life by electrical or mechanical self-excitation of inorganic combinations imitating living plasm.

In closing I can only refer to that new conception of the luminiferous ether foreshadowed in Mendelieff's "Chemical Conception of the Ether," and emphasized in Sir Oliver Lodge's very recent treatise on "The Ether of Space." This is the thought which I have myself endeavored to put forward; that the ether may not be different from matter but is literally the etherealization of that of which matter is the embodiment, whether, as in Kelvin's suggestion, matter rises from vortexes in the ether, or, as in Mendelieff's view, the ether may be the infinitely tenuous condition of chemical elements or of their final constituents, or, as in the theory of Thompson and Lodge, matter may be motions of the ether, from which not only a theory of matter but a theory of gravitation may be evolved. Sir Oliver Lodge goes so far in his commingling of psychology and physics as to suggest that here, in the ether pervading us and the universe, may be, in a fourth dimension of mathematics, that seat of the spiritual life which the authors of that remarkable book "The Unseen Universe" presaged. Thus the realms of spiritual mystery open to us in these vistas of the problems of the infinitely little. But indeed these be mysteries. Between matter and mind, between the dead and the live, so close to each other physically, there is still and may ever be the gap between the finite and the infinite—measureless. With all our science, we must still in modesty of spirit obey the words of the poet Robert Buchanan in the wonderful out-reachings of "The Book of Orm."

> "But still with those divine grave eyes
> Respect the realm of mysteries."

THE RELATION OF SNOW TO IRRIGATION AND FORESTRY

THE GREAT IMPORTANCE OF SNOW CONSERVATION AND THE METHODS USED FOR DETERMINING THE AMOUNT AND VALUE OF SNOWFALL

BY S. P. FERGUSSON

THE importance of accurate information concerning the amount and density of snowfall has been recognized only within recent years, and the application of methods of precision in experimental studies undertaken may be said to have begun within the past five years. At the present time the material gathered for study relates to but a few isolated places, and very probably, conclusions based upon these data will require modification when more complete information is available. The data employed in this paper were collected chiefly by Dr. J. E. Church, Jr., in what is probably the first systematic investigation of the relation of forests to snowfall and relate almost wholly to conditions in the Sierra Nevada Mountains in the vicinity of Lake Tahoe. It is believed, however, that some of the results, with a brief description of the methods employed in this work, will be of general interest.

In temperate latitudes an annual precipitation of about 500 mm. is considered sufficient for the needs of agriculture. This is the average amount occurring in a region comprising parts of Texas, Oklahoma, Kansas, Nebraska, and the Dakotas, central between the 93d and the 105th meridians. However, the variability of the rainfall in this region is so great that in times of extreme deficiency the natural rainfall must be supplemented by the methods of dry farming or by irrigation. East of this region the precipitation is abundant and seldom is so deficient as to cause partial failure of crops. To the west it decreases rapidly until in parts of the Central Basin, between the Rocky Mountains and the Sierra Nevadas, the average annual amount is less than 100 mm. Here, agriculture, horticulture, and forestry are almost wholly dependent upon irrigation, although in a few favored places dry farming has been moderately successful. The precipitation is extremely variable. In some instances nearly one-half the annual amount falls in two or three months, while the remainder of the year is relatively dry. Usually, the greater part occurs in the winter months, from November to April, in the form of snow, most of which falls on the western slopes of the high ranges, the amount increasing rapidly as the elevation increases. At the summit of the Sierras, at elevations of 2,500 to 3,500 metres, the annual depth of snow sometimes exceeds 15 metres and the amount on the ground at one time may exceed 10 metres. East of the summit, in valleys less than 40 kilometres distant, the annual amount may be less than one-tenth as much.

In the late spring the melting of the winter's accumulation of snow increases the flow of the streams to a maximum at the time the water is most needed for irrigation. In central and eastern Nevada this flood occurs in June while in the western part of the state it occurs in the latter part of May. The streams throughout the state are small and in some instances practically the entire average flow is utilized. To provide for future needs considerable attention is now being given to projects for the more efficient use of available sources of supply. Floods caused by sudden melting of snow during

"chinook" winds are, in many cases retained in reservoirs instead of being allowed to waste, and it is possible that overflows due to local storms or "cloud-bursts" may be utilized in a similar way, although such storms usually occur too late in the season to be of much use in irrigation. It is not possible to increase or decrease precipitation by artificial means and there is no trustworthy evidence that there has been an appreciable increase or decrease within the historic period. Nor does the evidence support the popular belief that precipitation is influenced by forests or vegetation; it appears more probable that vegetation is a result rather than a cause of precipitation.

From recent studies it seems probable that vegetation may be of value in the control of stream-flow particularly where the streams are dependent upon melting snow. To what extent this may be possible cannot be predicted at the present time, but the data obtained so far indicate that an experiment is well worth trying. The study of the relation of forests to snowfall was undertaken by Dr. Church in 1908 as a part of the work of the Nevada Agricultural Experiment Station, the cost of the work being paid from the Adams Fund. Numerous measurements of the depth and density of snow in forests of different kinds and in open spaces at elevations between 1,500 and 3,000 metres have been made, also, studies of the variations of temperature in deep snow and the evaporation under differing conditions have been undertaken.

These data indicate, that, in the Sierra Nevadas and probably in other regions a larger quantity of snow accumulates in forests than on bare slopes and that there is an appreciable difference in the amount retained by different kinds of trees. Also, dense forests do not retain snow quite so well as those where groups of trees alternate with open spaces. In the accompanying table are compared the amounts of snow—at different dates—in three conditions of forestation. The figures are averages of about 65 observations each.

Date 1910	Treeless Meadow		Forest of Pine and Fir		Fir Forest	
	Depth of Snow	Water	Depth of Snow	Water	Depth of Snow	Water
	mm.	mm.	mm.	mm.	mm.	mm.
January 7	625	165	605	160	635	137
19	1056	249	1026	213	—	—
March 11	757	297	798	307	772	279
21	523	213	610	239	622	229
April 10–13	0	0	—	—	—	—
20	0	0	33	15	180	69

Dr. Church suggests as an explanation of the superiority of the fir forest that snow does not collect on the foliage in sufficient quantity or remain long enough to suffer loss by evaporation, which, on account of the active circulation of the air at the height of the trees, is greater than that from snow on the ground. This appears to be confirmed by measurements of evaporation conducted on the slopes of Mount Rose.

The sheltering effect of the forest is quite well shown in the accompanying photograph of the southern slope of Mount Rose. The two groups of trees in the foreground are at an elevation of 2,300 to 2,500 metres above sea level, and are about 700 metres below the summit. Very little snow accumulates in the western group, and the largest amount apparently is deposited in the open space between the two groups. Snow does not remain permanently on the bare slopes within 300 metres of the summit, but is blown toward the southeast and east sides where it accumulates in the forests. A belt of scrub 500 metres below the summit on the north side retains snow until it covers the tops of the bushes, but since these seldom exceed one metre in height, the amount retained is relatively small.

Under ordinary conditions the measurement of rainfall is not difficult and the instruments necessary are neither complex nor expensive. Practically the only serious errors encountered are those due to faulty exposure of the instruments. The determination of the depth and density of snowfall is much more difficult. If snow always occurred during calms, measurement would be easy, but, unfor-

South face of Mt. Rose, Nevada, showing the effect of trees on drifting snow

tunately, snow storms are usually accompanied by high winds which are so modified in direction and velocity by topography that gauge readings in any one place do not give accurately the average amount for the vicinity. Even in years of normal snowfall slight variations in the mean direction and velocity of the wind may cause an artificial excess or deficiency in some places, hence, to obtain a satisfactory normal for any particular region it is necessary to make a large number of measurements and determine the probable error of the mean of these.

The use of this method in surveying the watershed of a large stream, especially if the region is mountainous, usually calls for the expenditure of much labor and money. Instruments ordinarily satisfactory at sea level are entirely inadequate in the deep compact snows of mountainous districts, and with the development of interest in the subject has come the need of special devices for rapid work in the field. Of the snow gauges tried within recent years the simplest is a board upon which is painted a suitable scale. Readings of a large number of these gauges suitably distributed should give a close approximation to the mean depth of snow; but a second measurement is necessary in order to determine the water-content, which is the ultimate purpose of the work. Hence, a method whereby both elements can be determined from one measurement is to be preferred. In 1908, Professor Bigelow of the United States Weather Bureau, devised a snow-bin consisting of a wooden box measuring about 1.5 metres each way, placed high enough above ground to escape drifting snow. These bins, like all forms of "catch" gauges having vertical sides, did not catch the true amount of snow nor did they retain snow that had fallen in them when an increase of wind occurred after a storm. It does not appear that wooden louvres secured outside or inside these bins were very effective in increasing the amount caught. The only form of "catch" gauge that is approximately accurate is the one designed in 1886 by the late Professor Rotch of Blue Hill

Observatory. As shown in figure 1, it is a sheet metal reservoir of any desired size into which snow falls through an aperture the diameter of which is but one-half that of the tank. When fitted with a Nipher screen, shown in figure 2, this instrument is fairly accurate even in moderate winds. This screen, invented in 1878 by Professor Nipher of Washington University, is made of coarse wire cloth of about 3 mm. mesh which breaks up the eddies of air about the mouth of the instrument. Rain gauges fitted with this screen and exposed at considerable heights above ground have given practically the same readings as instruments on the ground, and experiments at Blue Hill indicate that screened gauges sometimes catch 50 per cent. more snow than those not provided with screens.

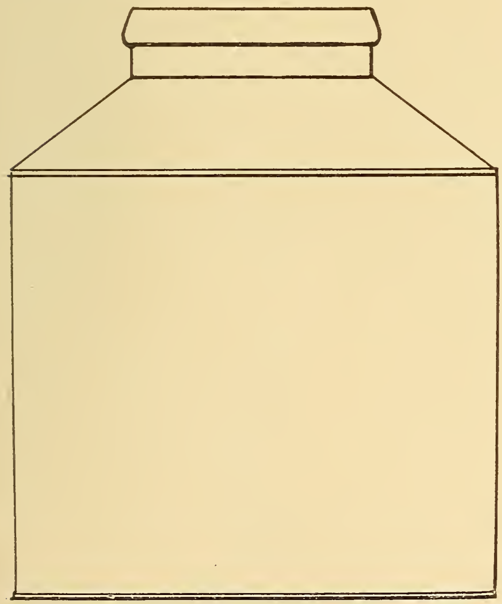


FIG. 1

On account of the cost and labor required to maintain instruments of the patterns described, it is probable that the well-known method of measurement by section is far more economical and efficient than any other in mountainous and sparsely settled regions. In its simplest form, as practised by observers of the Weather Bureau since 1885, this method consists of cutting a section by means of the overflow attachment of the standard rain gauge and determining the

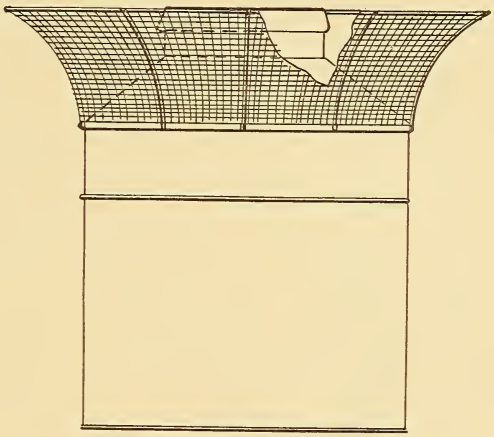


FIG. 2.

amount of water by melting and measuring it as rain. The writer does not know where precipitation was first measured by weighing, but weighing rain gauges were used in 1885 by Desmond FitzGerald at the Boston Water Works, and in 1886, the first weighing snow gauge was devised at Blue Hill Observatory.

In designing an instrument suitable for use in the heavy snows of the high Sierras Dr. Church first tried tubes made of sheet iron and fitted with steel cutters. These were entirely too weak and finally it became necessary to use seamless steel tubing. This material has proved to be amply strong although heavier than is desirable, and the instruments made from it, some of which have been employed in snow 6 metres deep, are very satisfactory. Details of the apparatus are shown in figures 3, 4, 5, 6, 7 and 8. The tube A may be of any convenient length, but usually where deep snow is to be measured it is made in two or more sections each 2 to 3 metres in length, which may be joined together as needed by means of screw couplings, B. Extending through the length of the tube is a

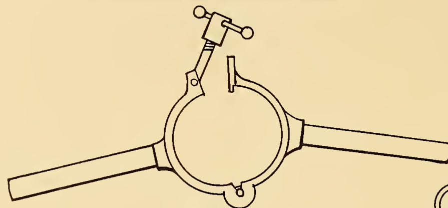


FIG. 5.

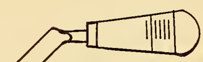


FIG. 6.

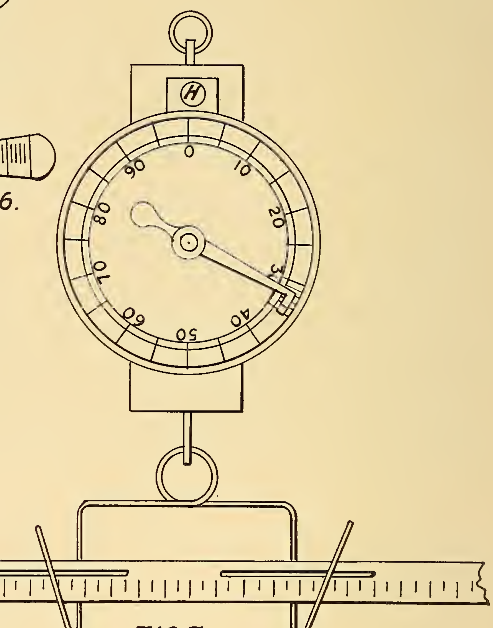


FIG. 7.

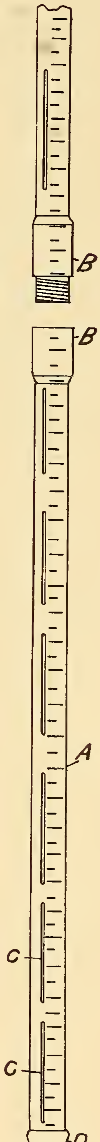


FIG. 3.

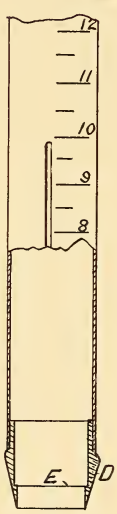


FIG. 4.

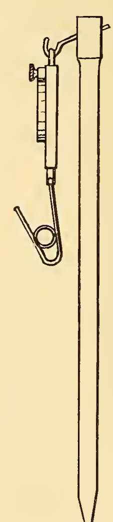


FIG. 8.

row of slots C, through which the length of the sample or core may be observed. The depth of the snow is indicated by a scale engraved upon the tube near the row of slots. The outside diameter of the tubes employed at present is $1\frac{3}{4}$ inches. The cutter D, which is soldered to the tube A, has an internal diameter of 1.5 inches for a space of about 3 mm. At E the diameter is increased about 2 mm., forming a narrow shoulder to prevent the sample from falling out when the instrument is withdrawn from a snow field. The sample is easily removed by nverting the tube, but any snow adhering may be dislodged by means of the tool shown in figure 6. The handle of this tool is also employed as a cylindrical gauge to detect any injury received by the cutter.

The water content of the sample is determined by weighting the tube and its core upon a spring scale, figure 7, the dial of which is ruled to indicate the depth of water instead of its weight. By means of a milled head H, the dial may be adjusted to read zero when the empty tube is supported by the scale, thereby simplifying the process of reading although there is no gain in accuracy. The index of the scale is a narrow strip of sheet metal with a line ruled upon its outer end so that estimates of fractional parts of inches or centimetres may be made with greater accuracy than is possible when the ordinary pointer is employed. The scale itself is a modified form of the well-known Forschner spring balance made of aluminum and weighing but two-fifths as much as the standard pattern. Usually it is accurate within about one or two tenths of one of the smallest divisions of the dial. For convenience in reading, the scale is hung on a staff, figure 8, which at other times may be used as an alpenstock or guide when traveling on skis.

A hinged wrench, figure 5, is sometimes necessary to drive the tube into deep compact snow. The weight of the entire equipment, including a sampler 6 metres in length, is about 12 kilograms and it can easily be carried by two men. Even in rough country several hundred measurements can be made in a day and a large region surveyed in a comparatively short time.

This instrument has been found satisfactory not only in the work of the Experiment Station, but also during a snow survey recently made for the Weather Bureau by Mr. H. S. Cole of the Reno Station.

As stated, the study of the relation of snow to irrigation is of comparatively recent origin and the results obtained up to the present time must be considered largely as indicating the methods to be followed in extending the research. The influence of forests of certain kinds upon the conservation of snow appears to be well established, from studies already made in natural forests. It is desirable now, to complete the work by planting new forests in favorable regions and measuring the effect upon neighboring streams.

COSTS OF CONCRETE BUILDINGS

Lockwood, Greene & Co., architects and engineers for industrial plants, Boston and Chicago, estimate the approximate unit costs of reinforced concrete buildings of various types as per the figures in the table below. These figures coming from a firm that has had such an extensive experience in this line are of more than usual value:

Type of Building	Dimensions	Live Load, pounds per sq. ft.	Cost above Foundation		Cost including foundation	
			Sq. Ft.	Cu. Ft.	Sq. Ft.	Cu. Ft.
Mch. Shop...	120x50 4 sto.	150	$1.05	$0.08	$1.17	$0.09
Mch. Shop ..	220x100 1 sto. sawtooth skylights		1.65	0.09	1.75	0.10
Cartridge.... Factory ...	223x56 2 sto.	300	1.40	0.09	1.55	0.10
Cotton Mill..	550x129 2 sto.	75	0.99	0.07	1.06	0.075
Weave Shed	341x231 1 sto. sawtooth skylights	125	1.66	0.064	1.79	0.07
Power Ho ...	90x62		2.53	0.115	2.67	0.12
Store Ho....	181x56 4 sto.	150	1.08	0.065	1.15	0.07
Store Ho	256x100 12 sto.	150	0.90	0.09	0.98	0.105
Store Ho ...	223x56 2 sto.	300 and 1,000	1.20	0.08	1.35	0.09

Coal pockets above 3,000 ton capacity cost from $6.00 to $7.50 per ton. Reinforced concrete stand-pipes above the foundation cost from $2\frac{1}{2}$ to 3 cents per gallon.

SWIMMING POOL SANITATION

SOME PRECAUTIONARY METHODS THAT ARE NECESSARY TO KEEP THE WATER OF SWIMMING POOLS IN PROPER SANITARY CONDITION

BY JOHN F. NORTON

Although at this writing the season of indoor swimming is nearly over and that of outdoor approaching, still it seems worth while to look back a few months in order to get, if possible, a few lessons which may be of some interest when we again put on the scanty bathing suit of the indoor pool and refresh ourselves at the public swimming tank or Y. M. C. A. after a hard day's labor. Besides, a good deal that can be said concerning the sanitation of the indoor tank could, with good results, be applied to outdoor swimming, particularly to some of the municipal bathing houses which are too often located near badly polluted harbors or rivers.

That swimming or bathing, whether outdoors or indoors, in water which is highly contaminated with human waste may be a means of spreading disease, is beyond question. First, there are certain intestinal troubles, such as typhoid fever, which may be contracted by swallowing polluted water. It must be admitted that the chances here are much less than with drinking-water owing to the smaller amount generally consumed, but these diseases have been at various times traced to bathing, and no one seems to be ready to state in definite terms what the allowable chances are as compared to drinking-water. For this latter purpose the standard usually taken is that if one or more bacteria belonging to sewage types, such as the colon bacillus, are found in one cubic centimeter (about 15 drops), the water is not safe to drink. It seems a little hard to judge water for bathing by this standard, but at present it is the only one we have.

Besides internal diseases there are certain infections of the skin and external mucous surfaces which may arise from swimming in contaminated water. The organisms causing these troubles get into the water from the bodies of other bathers. To prevent the spread of such diseases it is essential to prohibit the use of pools to known infected persons, to insist that everyone should be clean before entering the tank, and to make sure that all bathing suits are properly boiled after each use.

The ideal way to conduct a swimming pool would be to completely empty the tank, clean and refill it each day, but it is seldom possible to do this. In the first place the time required would make the pool much less useful than it should be, and, secondly, in many places the cost of water would make such a procedure prohibitive. It has, therefore, become quite general to install some sort of a purifying system intended to keep the tank in good condition.

Such system should comprise, first, an efficient means of cleaning the bottom and sides of the tank each day. This is done in some places by means of a brush or a piece of hose serving as a brush. A very good method, which recently came under the observation of the writer, consisted of an arrangement very similar to a vacuum cleaner by which the dirt and hair clinging to the tank was sucked out. This proved very efficient and easy to operate.

Second, there should be some way of keeping the water in good physical condition, that is clear and colorless. Generally the water is withdrawn from the

tank, passed through some sort of a filter and then returned for use. The arrangement is such that this is a continuous process, only a small part of the water being withdrawn at a time. The type of filter used varies considerably. Sometimes it consists of a bed of sand over which the water is sprayed, a method comparable to that used for sewage treatment. The suspended matter is retained by the sand and unstable organic matter is rendered stable. The more common types are, however, such as are used in water purification. These consist of one or more large drums filled with broken stone or cinders. Alum is added to the water just before it enters the filter. The alkali in the water causes a gelatinous precipitate of aluminum hydroxide to form which collects the suspended and coloring matter, and is caught in the stones as the water passes through the drum. The slimy deposit in the filter prevents the passage of very small particles, even bacteria being retained to the extent of about 80 per cent. If the operation is properly carried on, no alum should pass into the tank, where it would cause the water to become cloudy, but if some did get through no other trouble would follow, as alum, at least in the quantities liable to be used, is a perfectly harmless substance. The number of bacteria removed is not sufficient so that we can depend on this method for the entire purification.

Third, an indoor swimming pool is an excellent incubator for micro-organisms, as the temperature, usually about 70 °F., is favorable and enough food is supplied from the bodies of the bathers. Some further system must, therefore, be used in order to remove any dangerous organisms, and so prevent the spread of disease. The most efficient, cheapest and easiest thing to use is calcium hypochlorite,—the ordinary chloride of lime. This, even in small amounts, is a good germicide and is harmless to anyone using the water. To add it to the water it is necessary only to warp about a pound for each 50,000 gallons of water, in a piece of cheese cloth, tie it to the end of a pole, and draw it around the tank. The water will dissolve the chloride and the cheese cloth will hold back any large particles of foreign matter. It is best to do this the last thing at night so that there will be plenty of time for the disinfectant to act before the pool is again used and also so that the odor of the chloride will have entirely disappeared.

Another reason for allowing the tank to remain quiet for some hours is that large numbers of the bacteria will settle along with the dirt and other suspended matter, and will thus be removed in the morning when the tank is cleaned. In the opinion of the writer this sedimentation is one of the most important factors in keeping a pool bacterially clean, and will be, even in the absence of other methods of purification, a considerable safeguard against disease. It should be noted that the cleaning must be done regularly and efficiently and without stirring up the contents of the tank.

During the past winter the writer has had an opportunity to watch a swimming pool in which systems of cleaning, purifying and disinfecting, as above described, have been used simultaneously. The same water was used for a number of weeks, only enough fresh water being added each day to replace that lost by splashing and cleaning. This amounted to about one eleventh of the capacity of the tank. The filter was kept in operation during the daytime and was of such a capacity that the whole contents of the tank were filtered each day. At night chloride of lime was added, and in the morning the sides and bottom of the tank were cleaned by suction. Chemical and bacteriological examinations were made at intervals in order to study the extent of pollution of the water.

The actual figures obtained will not be given as many of them had no particular meaning, but certain conclusions were drawn from some of them. The first was that it is possible by efficient cleaning and filtration, to keep an indoor pool in excellent physical condition for an indefinite length of time. Second, that a disinfectant must be added in order to sufficiently remove the bacteria. Third, that this disinfectant is not troublesome

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to the swimmers, as no complaint was ever received from them. Fourth, that even with the addition of a disinfectant the number of bacteria will become excessive after a time—in the case of this particular pool about one month. The time would probably be greater or less, depending on the size of the tank and the number of people using it. Indications were that the increase of bacteria was due to the gradual development of a resistance to the disinfectant by one species of organism.

In conclusion it can be said that while the indoor swimming pool may become a source of danger, yet it is perfectly possible, by using the proper precautions to keep it clean, to reduce this danger to very nearly nothing. It will require some care and trouble and a little expense, but isn't it worth while?

WAGES IN VARIOUS COUNTRIES

FROM the results of thorough investigations undertaken by the Board of Trade, England, relating to the wages paid to workmen in England, Germany, France, Belgium and the United States, some interesting data on the comparative wages in these countries may be obtained. These data present a fair average, as not less than ninety-four industrial centers in Great Britain, thirty-three in Germany, thirty in France, fifteen in Belgium and twenty-eight in the United States furnish the basis for the comparison. As a general average it may be stated that the wages of American workmen are 50 per cent. higher than those of English workmen. In the European countries wages are highest in England and lowest in Belgium. English workmen are, in general, paid 25 per cent. more than German workmen, and 36 per cent. more than workmen in France. Relating to wages in the metal industries, the following figures will be of interest: Lathe hands are paid in London $9.50 per week of fifty-four hours; in Berlin, from $9.10 to $9.45 per week of from fifty-seven to sixty hours; in Sheffield, $9.25; in Düsseldorf, from $8.00 to $8.75; and in Antwerp, $5.85, for sixty hours a week. Of European countries, England shows not only the highest wages paid but also the shortest working hours. Belgium with the lowest wages has also the longest working hours. The investigation also covers the cost of living in the different countries. Thus, for example, rents for similar accommodations are nearly twice as high in England as in Belgium, and about twice as high in the United States as in England. The average prices of food products as compared with the English prices are 17 per cent. higher in Germany; 18 per cent. higher in France; 1 per cent. lower in Belgium; and 28 per cent. higher in the United States.

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VOL. III DECEMBER, 1912 No. 1

The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

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VOL. III JANUARY, 1913 No. 2

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The Aim of Science Conspectus

Not many years ago a man might say, " I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

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